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**4th International Conference of
Hyojeong Academy
21st International Conference
for Unification Medical Science
World Research Institute for
Science and technology**

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Keynote Speech

Two Paradigms on Unity of the Sciences and Unification Thought

Honorable and distinguished scholars, respected guests of this International Conference of Hyojeong Academia, ladies and gentlemen: It is a distinct honor for me to address you on the topic the “Two Paradigms on Unity of the Sciences and Unification Thought” at the beginning of this most significant international conference.

Through the movement of the unity of science, we know that scientists have tried to carry out the task and ideal of science for a long time. From Unification Thought perspective, scientists tried to realize this ideal while science progressed. During the 17th century, scientists and philosophers developed the idea of an encyclopedia, the predecessor of The Encyclopedia Britannica, based on the philosophy of enlightenment and mechanical materialism. Another later attempt to bring unity among the sciences centered on what was called the Vienna Circle. Together, the academic trends in the School of Encyclopedia and the Vienna Circle, which originated from the tradition of empirical epistemology and materialistic philosophy, were strong advocates of empirical reductionism.

As they saw it, the language of science would constitute no problem since it would ultimately be reduced to a set of quantitative empirical concepts. From this perspective, the unity of science would be attainable because all sciences would ultimately reduce to the most general science, or physics (physicalism). These concepts constituted the universal principle of the unity of the sciences at the Vienna Circle. By making science a single enterprise, epistemologically speaking, the unity of science could be achieved. The original thesis of the unity of science was based on the belief that all scientific concepts are definable in the strictest sense of positivistic language or physical language.

On the other hand, Prigogine, a winner of the Nobel Prize in Chemistry in 1977, asserted that modern science must be newly established based on the second law of thermodynamics, going beyond reductionism and precise measurement based on classical physics. He said people must restore the Greek method of thinking that described the cosmos as a work of art and break out of the classical method that describes it as an automatic mechanism. David Bohm, a quantum physicist, and one of the leading scientists of the movement of new science today, acknowledges the realistic, atomic or mechanistic view that thinks of material and spirit separately. However, he says nobody will deny that with the emergence of quantum mechanics there must be an implicit order behind matter and spirit, somewhat related to oriental thought. He believes that matter and spirit are not two separate beings but one substance of dual aspects on a higher level in the world of implicit order. He says there exists a certain aspect of the world that cannot be explained by a mechanism of causation. We can say that the essence of the experience of today’s physicists is beyond the realm of the classical concept of space and time.

As I mentioned above, two different paradigms are implicitly contained in Unification Thought. That is, a non-contradictory possible fusion of fact-value. To pursue a new model of science, we must go a step further and see that the relationship of matter and mind, the one and the whole, and fact and value, cannot

be conceived as a state of mutually exclusive opposition, but as two aspects of the same reality, which co-exist and are in continual co-operation.

Truth remains the goal of human inquiry. I sincerely hope we will, through our enthusiastic discussions, have great success in this International Conference of Hyojeong Academia, 2024. I pray for God's protection and blessing to be with you and your families. Thank you very much.

Dr. Jin Sung-Bae,
Chair of Hyojeong Academic Foundation

Congratulatory Message

It is a great honor to join you in the successful opening of the 4th Hyojeong International Academic Conference. I extend my heartfelt congratulations to the organizers, led by Dr. Pyun Young-sik, for their tireless efforts in convening this distinguished assembly. My sincere appreciation also goes to the scholars whose dedicated research has culminated in the presentations we are about to witness.

The 21st century, marked by the Fourth Industrial Revolution, has ushered in a period of unprecedented transformation. The COVID-19 pandemic of the past few years has profoundly impacted humanity, reshaping our lifestyles and perspectives.

Since the groundbreaking achievement of Google DeepMind's AlphaGo in 2016, which defeated a professional human Go champion, artificial intelligence has rapidly integrated into all academic fields and has become an essential part of our daily lives. However, the potential consequences of this technological revolution, such as the erosion of human dignity and the emergence of superintelligent AI, warrant careful consideration.

Moreover, the detrimental effects of climate change, intensified by carbon emissions, have become increasingly apparent. Extreme weather events and the ongoing conflicts in Ukraine and the Middle East serve as stark reminders of the challenges facing our world. Furthermore, the persistent tensions on the Korean Peninsula, characterized by nuclear proliferation, remain a significant source of concern.

Despite the complex and ever-evolving challenges we face, we gather here today to celebrate the power of human intellect. Approximately 100 academic papers will be presented at this conference. I extend my sincere gratitude to all the researchers. It is my hope that through their work, we will discover new values that can guide us towards a future of shared prosperity and coexistence.

I wish this conference a resounding success and extend my best wishes to all in attendance.

Thank you.

Dr. Moon Seong-Jae,
President of Sun Moon University

Proceedings of

**THE 4th INTERNATIONAL CONFERENCE OF
HYOJEONG ACADEMY 2024**



Session 1

**Environmental &
Social Studies
for C0-Existence**

Allometric Equations to Predict Aboveground Biomass and Carbon Stock of *Faidherbia albida* in Parkland Agroforestry

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Abstract: Maintaining trees on farmland improves the carbon sequestration potential of agricultural lands and contributes to global carbon balance. Samples of 35 trees were harvested for aboveground biomass (AGB) and carbon stock measurements in parkland agroforestry fields of eastern zone of Tigray, Northern Ethiopia. Allometric equations were developed using the regression models that related the total AGB with diameter at stump height (DSH), diameter at breast height (DBH) and a combination of DSH, DBH, height (H) and crown diameter (CD). The allometric model related to DBH, $\ln(\text{AGB}) = -2.85 + 2.4 \ln(\text{DBH})$, was considered the best fit, with the highest adj. R² (0.88) and lowest prediction residuals sum of squares (PRESS) (3.51 kg), bias (-2 kg), root mean square error (RMSE) (0.3 kg), and Akaike information criterion (AIC) at $P < 0.01$. To validate the best-fitting model for AGB estimation, cross-validation was performed. When assessed with the AGB of *F. albida* data sets from this work, the species-specific and multi-species previously published models substantially overestimated by 60% and underestimated by 50% respectively. *F. albida* total AGB was 3372.25 kg ha⁻¹ and 1584.96 kg ha⁻¹ of carbon for a density of 47 trees ha⁻¹ in the parklands. In the *F. albida*-based parkland farming system, our study identified patterns of carbon distribution in different tree sizes that may serve as a guide for programs that measure, report, and verify carbon stock and promote climate resilient farming system.

Keywords: Biomass equation, Climate change, Trees on farmland, Greenhouse gases

1. Introduction

Climate change is a worldwide phenomenon defined as long-term shifts in temperatures and weather patterns [1]. This weather change leads to intense heat waves and flooding, impacting human lives and livelihoods [2]. The primary cause of climate change since the 1800s has been human activity, mainly as a result of burning fossil fuels, which release gases such as carbon dioxide that trap heat [1]. The change in climate can affect agriculture; however, the agriculture sector also releases greenhouse gases into the atmosphere, which exacerbates climate change [3]. Agroforestry, which maintains trees on croplands as parklands, is essential for mitigating climate change because it sequesters carbon [4]. In addition to reducing the effects of climate change, subsistence farmers may benefit from the sale of carbon sequestered through trees on their farmlands under global carbon credit schemes and programs [5, 6]. This opportunity can be maximized by increasing the aboveground biomass (AGB) of trees in farmlands [7]. Therefore, the estimation of total above-ground biomass (TAGB) is an essential aspect of carbon stock and carbon sequestration [8]. The aboveground woody biomass of trees on farmlands can be quantified through direct and indirect measurements [4]. Direct measurement is a destructive harvest that involves the harvesting of all trees and measuring [9], but is expensive and impractical [10]. The other option for tree biomass quantification is indirect measurements using allometric equation, which is initially based on destructive sample trees related to measurable variables [2]. The use of an allometric model for biomass quantification is often the chosen method because it is less time consuming and cheaper than direct measurements [11]. Comparatively to general allometric models, applying species and site specific allometric equations to calculate the AGB of trees improves prediction accuracy [12]. Species-specific allometric equations exist for many tropical forest ecosystems [2], but they are not widely available for agroforestry trees, mainly scattered *Faidherbia albida* trees in the farmlands of Ethiopia [10]. Therefore, the objective of this study was to

develop species-specific allometric equations; compare the locally developed equations with the previously developed species-specific and multi-species allometric models outside the study area and compare the AGB carbon stocks across various tree size ranges in *F. albida*-based parkland agroforestry practices. Such information helps for better management of parklands and the monitoring, reporting and verification of strong allometric models that calculate the above-ground biomass of *F. albida* trees on farmers' fields.

2. Materials and Methods

The study was conducted in Ethiopia's eastern zone of Tigray. For the derivation of allometric equation and determination of carbon stock, a total of 35 trees were chosen for destructive sampling from four diameter at breast height (DBH) classes proportionally that is eight from <13 cm, eleven from 13 to 18 cm, nine from 18 to 23 cm, and seven trees from 23 to 31 cm. Based on the percentage of tree density and allowable cut tree size – as cutting large trees was not permitted, the number of trees sampled for each DBH class was determined. After felling the trees using a chainsaw, it was divided into three components: stem, branches and twigs plus foliage to facilitate fresh weight measurement. A composite of 400–500 g of sub-sample fresh biomass was taken in plastic bags and transported to the laboratory to be oven-dried at 70 °C for 24 hours in order to determine the dry matter content of the stems, branches, and foliages. The oven-dried samples were weighed and the fresh to oven-dry weight ratios calculated. The ratios were then utilized to convert each biomass component's field-measured fresh weights into oven-dry weights to obtain total dry aboveground biomass of the study tree species. Equation parameterization was done using R software version 3.6.1 [13].

2.1. Allometric Model Selection and Validation

Different equations were fitted to see relationship between aboveground biomass (kg dry matter per plant) and either stem diameter at stump height (DSH) or DBH alone and stepwise inclusion of height (H) and canopy diameter (CD). Fitted equation selection was carried out using the Akaike information criterion, AIC [14] and variance inflation factor (VIF). Coefficient of determination (R²) was also used to assess model fit for equations with one parameter, while equations with multiple parameters was assessed using the adjusted coefficient of determination (R²_{adj}) to reflect both the number of independent variables in the equation and the sample size. In order to validate the best fitting equation for each biomass component, a cross-validation technique was carried out [15]. Ideally, the models should be validated using an independent dataset; however, none is available for *F. albida* in the study area. The 35 *F. albida* plants were split into two groups for the cross-validation technique, with 70% used for "training" (i.e., 24 trees for constructing models) and the remaining 30% used for "testing" (i.e., 11 trees) the equations. The predicted and observed biomasses for the eleven "test" plants were compared with those obtained using the entire group of 35 *F. albida* plants, as well as the goodness-of-fit statistics and model coefficients from the "training" set.

2.2. Comparison Aboveground Biomass Models with Previously Published Models

Through a review of the literature, multi-species allometric equations potentially applicable for predicting AGB in Ethiopia and with the equations for *F. albida* developed by [16] and [11] in Africa were selected. Thus, the performance of published equations compared to our observed data and best fit *F. albida* allometric model developed in this study were assessed. Further, previously developed general multispecies models developed by [17] and [18] in natural forest and community exclosures of Tigray, Ethiopia was applied on this study dataset. Estimates from these models were evaluated for bias (the average relative error) as bias (estimated - measured/measured) x 100.

2.3. Biomass Data Analysis

Each plant's total aboveground biomass (AGB) was computed by adding the biomass of each component. The data were checked for normality and homogeneity. Based on the inventory data, *F. albida*'s AGB predicted. To evaluate the effect of *F. albida* tree size on biomass and carbon stock, one-way analysis of variance (ANOVA) was used with LSD (Least square means difference Gabriel test) to compare the mean biomass and carbon stocks at different DBH levels with a fixed effect model at (P < 0.05). AGB estimates in inventory plots (50 × 50 m) were multiplied by the default carbon proportion of 0.47 to calculate carbon stock [1].

3. Results

3.1. *Faidherbia albida* Plant Biomass

The statistical summary for the measured parameters and dry matter of the harvested *F. albida* plant samples are given in Table 1. The diameter at breast height of the samples varied between 8 cm to 31 cm with a mean of 18 cm. The lowest values of DSH, H and CD were 8.7 cm, 3 m and 2.43 m and the maximum values of the parameters were 38.8 cm, 11.5 m and 6.9 m respectively. The total above ground biomass varied from 0.97 to 262.83 kg tree⁻¹ with mean value of 71.75 kg tree⁻¹ for the entire range of measured data set. The stem component accounted for 76.29%, branch 22.49% and foliage 1.21% from the aboveground total plant biomass on average.

Table 1. Summary statistics of biometric parameters and dry matter (kg tree⁻¹) from the total aboveground and biomass components of harvested *F. albida* plant samples (n = 35)

Parameter	Unit	Mean	Minimum	Maximum	SD (±)
DBH	cm	18	8	31	6.2
DSH	cm	21.98	8.7	38.8	7.9
H	m	6.05	3	11.5	1.8
CD	m	4.46	2.43	6.9	4.46
Components	Mean (kg tree ⁻¹)	Minimum (kg tree ⁻¹)	Maximum (kg tree ⁻¹)	SD (±)	
Foliage	0.87	0.02	10.1	1.86	
Branches	16.14	0.25	88.76	15.83	
Stem	54.74	0.31	164.43	46.76	
Total AGB	71.75	0.97	262.83	59.51	

Where DBH is diameter at breast height, DSH is stump diameter at 10 cm height, H is total height, CD is crown diameter and AGB is above ground biomass.

3.2. Biomass Models and Cross Validation

Six candidate equations for predicting aboveground biomass of *F. albida* were constructed. For the total aboveground biomass, three equations were ranked best overall as a candidate model to be cross validated. Across all equations the parameter a_0 , a_1 or a_2 describing the influence of diameter (either DSH or DBH) plus height was significant ($p < 0.001$) while in equations that also included crown diameter, the parameter for crown diameter (a_3) was not significant. However, for estimating total aboveground biomass the formula using stump height diameter had the highest RMSE and PRESS made less fit model.

When the candidate models were computed with cross-validation of “training” and “test” datasets, the inclusion of parameter height did not show consistent performance as the b_1 coefficient become not significant ($P < 0.05$) for two candidate models. Hence, the model that contained only diameter at breast height was selected as the best fit model. The a_1 coefficient for the selected exponential model produced with cross-validation “training” *F. albida* plants ($n = 24$) was 2.72 for the total aboveground biomass. This changed little from those resulting with the whole group of *F. albida* plants and the biomass of the eleven “test” *F. albida* plants estimated with the cross-validation equations resulted with the full set of *F. albida* plants. The difference in the biomass predicts between the two sets of equations was overestimated by 0.64% for the total aboveground biomass of *F. albida* plants.

3.3. Comparison of the Aboveground Biomass Equations with Previously Published Models

We produced six candidate models to forecast the total aboveground biomass of *F. albida* plants. The allometric model linked to DBH, $\ln(\text{AGB}) = -2.85 + 2.4 \ln(\text{DBH})$, was deemed to be the best fit among the six candidate models, with the lowest PRESS (3.51 kg), bias (-2 kg), root mean square error (RMSE) (0.3 kg), and Akaike information criterion (AIC) at $P < 0.01$. It also had the highest adj. R^2 (0.88). The general models that were previously published overestimated our data set by over 60%, or higher than the results generated by our model M1 equation. Nonetheless, there was a 56.9% and 66.64% underestimation of the species-specific and multi-

species growth rates in the exclosures in Tigray, respectively. While the *F. albida* equation created outside of the study significantly underestimated the total aboveground biomass of our *F. albida* observed data sets by 30.8% and 4.35%, respectively.

3.4. Tree Biomass Carbon Stock of *Faidherbia albida* Based Parkland Agroforestry

Faidherbia albida tree components such as stem (76.29 %) and branch (22.49 %) contributions combined for a mean above-ground biomass of 71.75 kg tree⁻¹ (Table 1). Biomass and carbon stock were significantly higher in 23 – 31 cm and 18 – 23 cm DBH levels than 8 – 13 cm DBH tree size of *F. albida* at ($P < 0.001$). Trees with larger DBH were capable to sequester more carbon than trees with smaller DBH with 75.43, 38.61, 21.59 and 8.41kg tree⁻¹ for the four DBH classes respectively (Figure 1). Based on the field inventory, 47 *F. albida* trees per hectare were found in the agroforestry parkland system. Our allometric equation estimate for the above-ground biomass of these trees was 3372.25 kg ha⁻¹, and the study's findings indicate that trees store 1584.96 kg of carbon ha⁻¹ in their above-ground biomass. The predicted increase in above-ground carbon of *F. albida* trees would be 3372.25 kg, assuming a potential rise in tree population density to 100 trees per ha through plantation or natural regeneration.

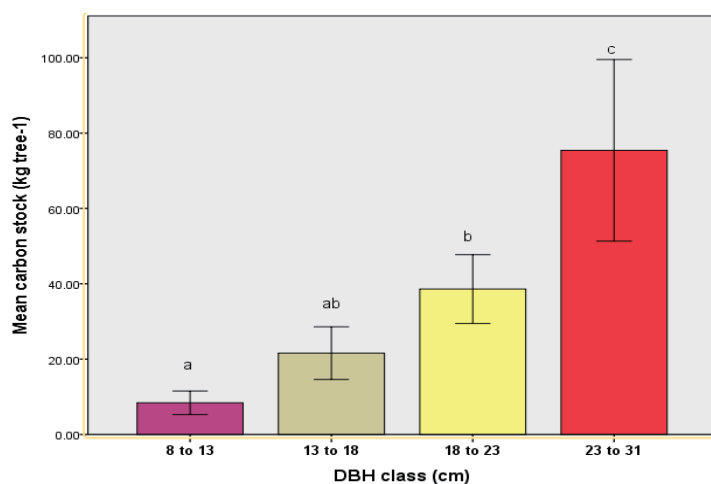


Figure 1. Mean carbon stock comparison across DBH classes of *F. albida* tree. Different letters show differences between mean carbon stock of trees sizes (post-hoc Gabriel test, $p < 0.05$).

4. Discussion

4.1. Species-Specific Aboveground Biomass Allometric Equations for *F. albida* Based Parkland Agroforestry Practices

Very few studies, especially in agroforestry systems, have examined the biomass of *F. albida*. Numerous factors, such as plant architecture and morphology, tree size, climatic and edaphic factors, and, in the case of agroforestry systems, management practice, influence the biomass and distribution among components of woody plants [4, 11, 16, 19]. Dilla et al. [19] reported the biomass of *F. albida* in the central rift valley of Ethiopia, noting that 81.2% of the aboveground biomass was made up of woody components (stems and branches), with the remaining biomass being leaf biomass. Our study's stem plus branch biomass accounted for 98% of the aboveground biomass, suggesting that Ethiopian *Faidherbia albida* parklands are similar in terms of forms.

Our findings also show that DBH is a strong predictor of AGB, which is consistent with previous reports [2, 20-23], implying that DBH alone is a good predictor of biomass, particularly when multiple trade-offs between precision, price, and measurement practicability are discussed. And it was also suggested that a model be used in which tree biomass is measured solely by DSH, which had a practical advantage for inventories of biomass for multi-stem shrubs compared to trees, e.g., *Coffea arabica* [4] and *Rhamnus prinoides* [24]. Although measuring DSH was also easy, DBH was the best-fit independent variable for developing the allometric model of the *F. albida* tree at the study sites.

4.2. Allometric model comparison

The generated best fit species-specific allometric equation of our study produced the lowest prediction error (MPE) for *F. albida* when compared to the previously developed multi-species and species-specific biomass estimate models. As [23] noted, even though generalized allometric models exist for multiple species and sites, the application of these models should be used with care as the site highly impacts AGB estimations.

Our study also confirms that existing multispecies models established for drylands, agricultural landscapes and species-specific areas outside the current study area considerably over-predicted the observed AGB of *F. albida*, whereas the majority of species-specific models generated for other species in the agroforestry systems and exclosures in our study area under-predicted it. This is in line with the studies of [24] and [18], found 18 to 105% overprediction when testing their data set against previously developed multi-species models. Further, in agreement with our finding, significant bias was reported when the model by [25] was used to estimate the AGB of *F. albida* tree in the parkland systems of the rift-valley of Ethiopia [19]. The increased bias of existing multi-species and species-specific models may be due to species architecture and morphology, climate and management differences [23].

4.3. Biomass Carbon Stock of the *F. albida* Based Parkland Agroforestry Practices

This study shows that the mean total C stocks of *F. albida* trees rise from the lowest DBH class (8–13 cm) to the greatest (31 cm), from 8.41 to 75.43 kg/tree. This shows that biomass and carbon stock rise with individual tree size. These findings support those of [26], who discovered that age classes and an individual's maturity status have an impact on AGB production and that as a tree's DBH ages, so do its biomass and carbon stocks.

Our study found that *F. albida* trees stored roughly 1.6 t of carbon ha⁻¹ in AGB, while many findings show that *F. albida* parkland systems can store substantially more carbon. Beedy et al. [11] and Dilla et al. [19], for example, *F. albida* trees in the central rift valley of Ethiopia and Malawian parkland agroforestry systems revealed an average above-ground biomass carbon of 2 and 3 t C ha⁻¹, respectively. These disparities in estimates could be explained in part by large variances in tree sizes; for example, tree sizes explained by DBH in Mali parkland reached 116 cm, with a mode of 40 to 50 cm, but in the current research, tree DBH ranges from 5 to 31 cm. While the variation in tree size between our study and that of central rift valley of Ethiopia is approximately twofold, the DBH ranges from 50 to 55 cm with a mean of 53 cm. The reduced above-ground carbon storage in our finding could possibly be attributable to the pruning procedure, in which tree branches are clipped (pollarded) for fuelwood and fencing crop lands. As a result, continuous pruning and removal of carbon stored in tree components, such as leaves and branches diminishes carbon sequestration and slows tree growth rate [19].

5. Conclusions

This work presents a new species-specific biomass allometric model for *F. albida* and reports on AGB and carbon stock capacity of *F. albida* in the agroforestry parklands in Eastern Tigray, Ethiopia. Species-specific allometric models established to forecast the total AGB and carbon stock of *F. albida* using diameter at breast height (DBH) proved to be reliable and confident. The current study's allometric model adds to the assessment of biomass buildup in parkland agroforestry practices. Maintaining the optimal number and larger tree sizes of *F. albida* trees in agricultural areas has the potential to improve carbon storage and mitigate climate change. In developing countries like Ethiopia, which rely heavily on agriculture and natural resources, increasing carbon stores in farmlands could be a viable alternative for mitigating and adapting the effects of climate change and assisting in achieving the monitoring, reporting and verification objectives of REDD+ programs. Farming methods that contain trees with carbon stock potential, such as *F. albida* agroforestry, should be explored and scaled up in similar areas worldwide.

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Ethnobotanical knowledge on the use of dragon trees in pastoral communities of Afar, Ethiopia

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Abstract: Dragon trees have multiple uses. Documentation and analysis of ethnobotanical indigenous knowledge of communities on the use of dragon trees are vital to conserving these flagship species. This study was conducted to assess and document ethnobotanical knowledge on the use of *Dracaena ombet* and identify socioeconomic factors that control the ethnobotanical knowledge in pastoral areas of Ethiopia. Data were collected from 217 respondents using semi-structured interviews and focused group discussions. The association between socioeconomic variables and use knowledge of households was analyzed by multiple linear regressions and generalized linear mixed models. *Dracaena ombet* is a multifunctional species used for making various utensils, beehives, construction materials, medicine, gum and resin, food and fodder. The majority (>85%) of the products are harvested from stem part. Parents are the main source of ethnobotanical knowledge. Socio-economic variables have an impact on the household knowledge. The level of ethnobotanical knowledge varied significantly ($p \leq 0.01$) among households due to differences in age. Given the various uses, the need to protect the species is high. Conserving this species will allow pastoral households to obtain the benefits from the species.

Keywords: Indigenous knowledge, conservation, *Dracaena ombet*, household, multiple functions

1. Introduction

Dracaena species are among dragon trees, classified in the family Asparagaceae subfamily Nolinoideae and composed of 60-190 species. Globally about 10 *Dracaena* species of which *Dracaena ombet* is found in Djibouti, Ethiopia, Eritrea, Somalia, Sudan, Saudi Arabia, Egypt, and Yemen, at the altitude range from 1,000-1,800 meter above sea level [1]. The species is listed in the International Union for Conservation of Nature Red List as globally threatened [2]. It is a native species in the drylands of the north-east African region [3, 4]. It provides economic and ecological uses [4, 5]. People in north-eastern Africa and Arabia use *D. ombet* as a source of food [4], medicine, fodder [6]. However, *D. ombet* is threatened by over exploitation, climate change [2, 7], cutting, debarking and defoliation [8].

Ethnobotanical studies require identifying and understanding of sociocultural values of the plant species [9], and the ethnobotanical knowledge (EK) of people [10]. These procedure is followed to identify uses values of the plants and the knowledge of the local people which are important for conservation [10, 11]. The socioeconomic situation is vital to understand the knowledge the species [12]. Recent reports showed that socioeconomic factors have influenced the ethnobotanical knowledge. People with higher EK have lower levels of education and unspecialized jobs [13]. Such people usually have large families, low wealth status, and few material goods and they live in localities with low infrastructure [13, 14]. Similarly, older people have more EK, and people who acquired EK through their family route are endowed with the highest EK [15, 16].

In Ethiopian dryland areas, pastoralists have knowledge about their environments. Though, with the advancement of socioeconomic conditions, indigenous knowledge face risks of depletion. Drylands are a center for endemic plants, and local communities are gifted with ethnobotanical knowledge [16]. *D. ombet* is found in the dry Afromontane forests and eastern escarpment of Ethiopia [17]. However, information on ethnobotanical

knowledge to use *D. ombet* [4, 7], and socioeconomic dynamics which have been affecting the knowledge [18] is still lacking. Understanding ethnobotanical knowledge dynamics which is important to identify indigenous harvesting schemes of *D. ombet* [4], and its association to socioeconomic factors are required [19]. Therefore, this study was conducted to document ethnobotanical knowledge on the use of *D. ombet* and analyzes the influence of socioeconomic variables to use knowledge of local communities in Afar, Ethiopia.

2. Materials and Methods

2.1. Research design and methods

An ethnobotanical study approach was used to achieve the study objectives. This approach encompasses both survey and participatory approach. It is suitable for our study which was focused on the assessment of the ethnobotanical knowledge to use *D. ombet* [19], and analyze variation of knowledge among the households. A reconnaissance survey was conducted in June 2022 to obtain an overview of the availability, and use practices of *D. ombet* [16]. Purposeful sampling procedure was used to select study area based on the availability of *D. ombet* and ethnobotanical use practices [16]. The sample size was determined following [20], 217 household heads were participated. Ethnobotanical data were collected between July 2022 and December 2023 using semi-structured interviews, field observations and focus group discussions (FGDs) [21]. Percentage, mean, standard deviation were used to organize and describe the data set. The use value (UV) of the species was calculated [21]. The t-test and Pearson correlation for the categorical and continuous variables were also computed respectively [13, 22]. Multiple linear regression (MLR) models were used to understand the relationship between 14 socioeconomic variables and the EK of households [13, 16, 23, 24], and the effect of the variables on the EK was identified by generalized linear mixed models (GLM) [13].

3. Results

3.1. Sociodemographic of the households

Based on the results, 85.3% (185) of the households were male, while 14.7% (32) were female households. The results showed that 81.1% (176) of households are illiterate and the remaining 18.9% (41 households) attained informal education and can read. The age group of the households was categorized into 31-40, 41-50 and 51-65 years, and this age group constituted approximately 30%, 49.5% and 20.5% households respectively. Most of the households are pastoralists (approximately 43.8%), others are agro-pastoral engaged in various livelihood activities such as harvesting forest products (31.3%), off-farm activities (2.8%), trade (10.6%), wage (7.4%) and remittance (4.1%). About 17% of the households are with high economic status and 24% of them are grouped in middle status and low status (59%).

3.2. Multiple functions and knowledge sources to use of *D. ombet*

The collection of plant parts was accomplished on the wild *D. ombet* plant commonly called *Asera* or *Aserayto* in the Afar language. *D. ombet* is a multifunctional tree with a socioeconomic contribution to pastoral livelihood. *D. ombet* provides material for making household utensils, beehives, construction materials, gum, and resin, and has a medicinal value in all the study villages. The majority of the households (95%) agreed on the multiple uses of *D. ombet* and the species has social and cultural use values. The uses of *D. ombet* reported by the households were grouped into seven use categories (i.e., utensils (milking material, food plate, cheese storage), beehives, construction materials, gum, and resin, and medicinal, food, and fodder). The food plate is a commonly used indigenous utensil produced from the stem part. It is called *Koora* in Afar language, Ethiopia and used to supply porridge. A milking tub (*Horde*) is another utensil produced from the stem part of *D. ombet* for milking cows, goats, sheep, and camels. The other product is *Arari* which is used to store cheese. *Arari* is also harvested from the stem part of *D. ombet*. Locally beehive is called *Goodu*, produced from stem part of *D. ombet*. The beehive produced from *D. ombet* is lightweight and easily portable. The use of *D. ombet* for construction purposes was mentioned by 20% of the households. The pastoral people use the stem and leaf part of *D. ombet* for construction. Stems and leaf parts used to build gates of houses and shelter for livestock. *D. ombet* is used to harvest gum and resin; children collect

the red resin and use it as gum. The gum is used to heal wounds and to get relief from toothache. The patients chew the gum for 1-3 days. The stem and leaf parts are used to heal wounds and pain. Matured fruit of *D. ombet* is consumed by the local people during drought season. The matured fruits are consumed by poor individuals and seeds are also consumed by camel (52%) goats (38%) and sheep (10%). More than 70% of households acknowledged use of products from *D. ombet* for income generation. Four types of knowledge sources were identified and parents are highest source of EK than observation, learning and trial error.

3.3. Association of socioeconomic variables with ethnobotanical knowledge of households

Association between the EK to use *D. ombet* and socioeconomic variables was analyzed (Tables 1, 2 and Figure 1). Age of households, sex of households, household size, wealth status, and number of livestock had a significant relationship with the EK of the households ($p \leq 0.01$). Distance from the forest and extension service had a significant relationship with EK of the households ($p \leq 0.05$). Market distance from home and time of residency in the villages were significant source of variation ($p \leq 0.10$) on the EK the households. Educational status, EK acquisition method, participatory forest management (PFM) membership and source of income were not source of EK variation (Table 1).

Table 1. Relationship between socioeconomic variables and ethnobotanical knowledge using multiple regressions

Variables	Beta	t	p-value
(Constant)		-0.184	0.854
Age of respondents	0.288	7.106	0.000***
Sex of respondents	0.143	4.235	0.000***
Educational status	0.040	1.213	0.226
Household size	0.183	3.743	0.000***
Market distance	0.135	1.661	0.098*
Forest distance	- 0.170	- 2.165	0.032**
Time of residency	0.086	1.885	0.061*
EK acquiring method	- 0.056	- 1.029	0.305
PFM membership	- 0.094	- 1.445	0.150
Extension services	0.147	2.221	0.027**
Source of income	- 0.038	- 1.096	0.274
Wealth status	- 0.145	- 3.619	0.000***
Number of livestock	0.498	12.531	0.000***
Location	0.060	1.020	0.309

***statistically significant at $p \leq 0.01$, and ** $p \leq 0.05$

Table 2. Mixed-model effects of ethnobotanical knowledge and coefficients of the variables ($p \leq 0.01$, ** $p \leq 0.05$)

Variables	f-value	p-value
Intercept	46147.95	0.000
Age	134.6**	0.000**
Gender	132.04**	0.000**
Educational status	17.65**	0.000**
Household size	25.62**	0.000**
Market distance	32.24**	0.000**
Forest distance	30.4**	0.000**
Time of residence	34.43**	0.000**
EK acquisition	9.93**	0.002**
PFM membership	3.11	0.079
Extension service	36.2**	0.000**
Source of income	0.85	0.429
Wealth status	1.15	0.285
Site	0.01	0.915
Number of livestock	28.86**	0.000**

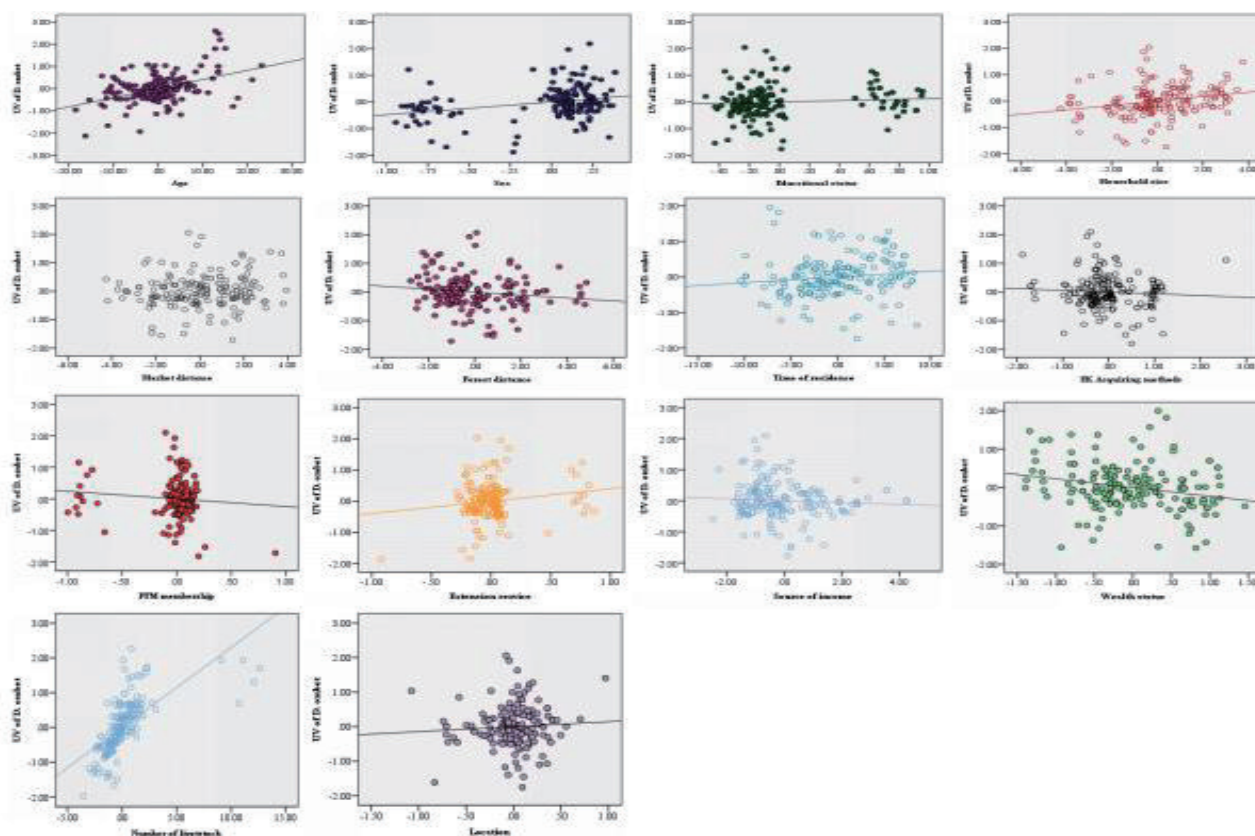


Figure 1. Scatter plot showing the UV as the response variable and age, sex, educational status, household size, market distance, and forest distance from the home of households.

4. Discussion and Conclusion

The local people are endowed with ethnobotanical knowledge to use *D. ombet*. The local people have special connections with EK [18, 25], and were commonly acquired through family routes, education, trial-and-error, and observation. The family route is a major contributor to documenting and preserving EK [16]. *D. ombet* has various uses [26]. The local communities use its parts to produce various materials [4, 27], the latex used for medicine, gum and resin production [4], stem for utensils, construction and beehive production. The fruit of the species is consumed by pastoral communities in drought season [28]. Among the products, utensils are unique and peculiar products in pastoral areas, even though we don't find any scientific report like our findings. However, the production system of the local producers is not controlled, and the species is ineffectively used. Even if the species can adapt to harsh environmental conditions, it is in a critical condition [29].

Socioeconomic factors are essential to understand the EK of local people to use different plants. EK and age of households had a significant association and it was consistent with different studies which indicated household heads with older age have greater EK than the younger household heads [23]. There is a logic that with increasing age, people have better opportunities to accumulate EK and therefore, show greater knowledge than the younger generation (Figure 1) [13]. Several studies that were employed on EK of medicinal plants in different parts of the world indicated the greater EK of men than women [16]. However, the studies by [23], came up with no significant correlation between gender and EK of medicinal plants. On the other hand, similar and equal EK between Aba'a and Gala'to women was observed and this might be due to the close interaction of the local community members with the forest [23]. We don't found significant association between educational status and EK of the households, but in contrary to our findings the study by [13], reported strong negative association to EK. Household size, wealth status, time of residence, and methods of EK acquisition have a positive relationship with EK [16]. The EK to use *D. ombet* becomes higher as the number of livestock owned by the household increases. This might be due to the mobility of the households to various areas to find food and water for their livestock. The

time of residency, and EK acquisition methods had a significant relationship with the EK of the households [13]. The EK is also varied among households' residence time. The level of EK increases as the residence time duration in each area increases. The households stay for a long time and get an opportunity to interact and familiarize themselves with the natural environment and used to increase their EK to use the resources within the environment. EK between PFM members and non-members was not varied. The same trend was observed between households found at different location and with different sources of income [24]. Generally, men had higher EK than women, and this was in line with earlier studies in different parts of the world [13].

In conclusion, this study showed that the local communities have important methods to acquire ethnobotanical knowledge to use *D. ombet*. The species contributes to household income to the pastoral communities. Socioeconomic factors have a strong influence on the level of ethnobotanical knowledge in the study area. Our research showed that male households with older age and longer time of residency had higher knowledge and these factors can have an impact on the *D. ombet*. Therefore, anybody who is concerned with social and conservation issues of plant resources, at national, regional and international levels, should consider the engagement of ethnobotanical knowledge bearers in all stages of the programs.

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Availability of data and materials: Please contact the author for data requests.

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Impacts of Traditional Gold Mining practices on Ecosystem Functions and Options for Restoration of Post-mining Ecosystems in the Drylands: A Review and Synthesis

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Abstract: Traditional gold mining (TGM) commonly implemented in developing countries that resulted in adverse ecosystem degradation. Sustainable management of the ecosystem requires understanding of the overall TGM approach and its ecosystem impacts. This paper systematically reviewed the methods and processes of TGM practice and its impact on agricultural lands and soil quality, vegetation cover, carbon stock, and arbuscular mycorrhizal fungi (AMF). The potential options for restoration of the degraded post-mined landscapes were also addressed. A total of 113 research materials, published from 2000 to 2023 were retrieved. The destructive and arbitrary nature of TGM practice has reduced considerable size of agricultural land, ranging from 25.8 ha to 4,935 ha. TGM practice significantly depleted essential plant nutrients and released heavy metals to the soil surface. Deforestation due to mining practices caused vegetation cover loss from 3,168 ha to 14,820,000 ha, which had a negative trend in the plant and soil carbon stock. TGM causes significant deterioration of beneficial soil microorganisms like AMF. The common post-mined restoration strategies are Phytoremediation, establishment of native plants assisted with organic matter application and inoculation with AMF. There are inconsistent research results regarding the impact of TGM on AMF that could be a future research hotspot.

Keywords: Agricultural lands, Arbuscular mycorrhizal fungi, Carbon stock, Deforestation, post-mined restoration, soil quality

1. Introduction

Land and/or ecosystem degradation has become a global problem in most terrestrial biomes and agroecologies [1, 2]. Irresponsible TGM practice is among the principal causes of ecosystem degradation processes [3-7]. Lack of capital and unskilled manpower integrated with poverty resulted in an intensification of traditional gold mining activities [4, 6, 8-12]. TGM causes persistent ecosystem degradation through shrinkage of agricultural lands; deterioration of soil quality; deforestation and carbon loss; and destruction of microbial communities [13-15]. Many scholars [9, 12-14, 16-20] attempted to investigate impacts of TGM practice on the ecosystem degradation. They come up with various but inconsistent research results. There are also various research experiences that illustrated the importance of AMF inoculation for restoration of post-mined landscapes [15, 21-27].

There are inconsistency research results [22, 26, 28] that reported AMF abundant and diversity can be deteriorated due to the destructive nature of TGM practice and other study claimed [27, 29-31] AMF could tolerate to the environmental stresses driven from TGM practice. To reverse the ecosystem degradation, there are several research experiences of post-mining restoration mechanisms. This paper intends to comply, review, synthesize, and analyze various TGM practice-related research experiences on impacts of TGM practice: 1. on agricultural land shrinkage and soil quality; 2. on deforestation, soil, and plant carbon stock; 3. on AMF community; 4. This paper also attempted to address the potential options for the restoration of TGM landscapes.

2. Data collection methods and analysis

This desk-work follows the systematic and comprehensive collection of secondary data related to TGM practice and its impact on agricultural lands and soil quality; vegetation and carbon stock; AMF; and post-mined landscape restoration mechanisms. The keywords used to retrieve the relevant literatures include the following strings: “artisanal gold mining OR traditional gold mining”; traditional mining NOT large-scale mining”; “traditional gold mining AND land degradation AND/OR ecosystem degradation”; “artisanal gold mining AND land use land cover change”, “traditional gold mining AND deforestation”; “traditional gold mining AND Carbon stock”, “artisanal mining AND soil quality”, “artisanal mining AND arbuscular mycorrhizal fungi”; “post-mining restoration”. A Total of 113 research materials were retrieved that were published from 2000 to 2023 (Figure 1) consistent with review objectives (Figure 1). Data were collected using search engines like Research Gate (<https://www.researchgate.net>), Google Scholar (scholar.google.com), Science hub (<http://sci-hub.tw/>), Wiley online library (<https://onlinelibrary.wiley.com/>), Elsevier Science Direct, web of science, and JSTOR.

The complied research was analyzed qualitatively through preparation, organization, and reporting phases. The preparation phase involved deciding on the unit of analysis and obtaining a thorough understanding of the data. Each article was carefully read to get a thorough understanding of the issues being described. The organization phase involved open coding to identify themes and categories from the data. The coding process involved thoroughly reading each article and taking summary notes. The summary notes for each article which expressed thoughts, and themes in relevance to the objectives of the study were given identities. Individual articles from the collected literature were, therefore, grouped concerning the research objectives (Figure 1). The reporting phase includes presenting and discussing the review results according to the objectives of the study

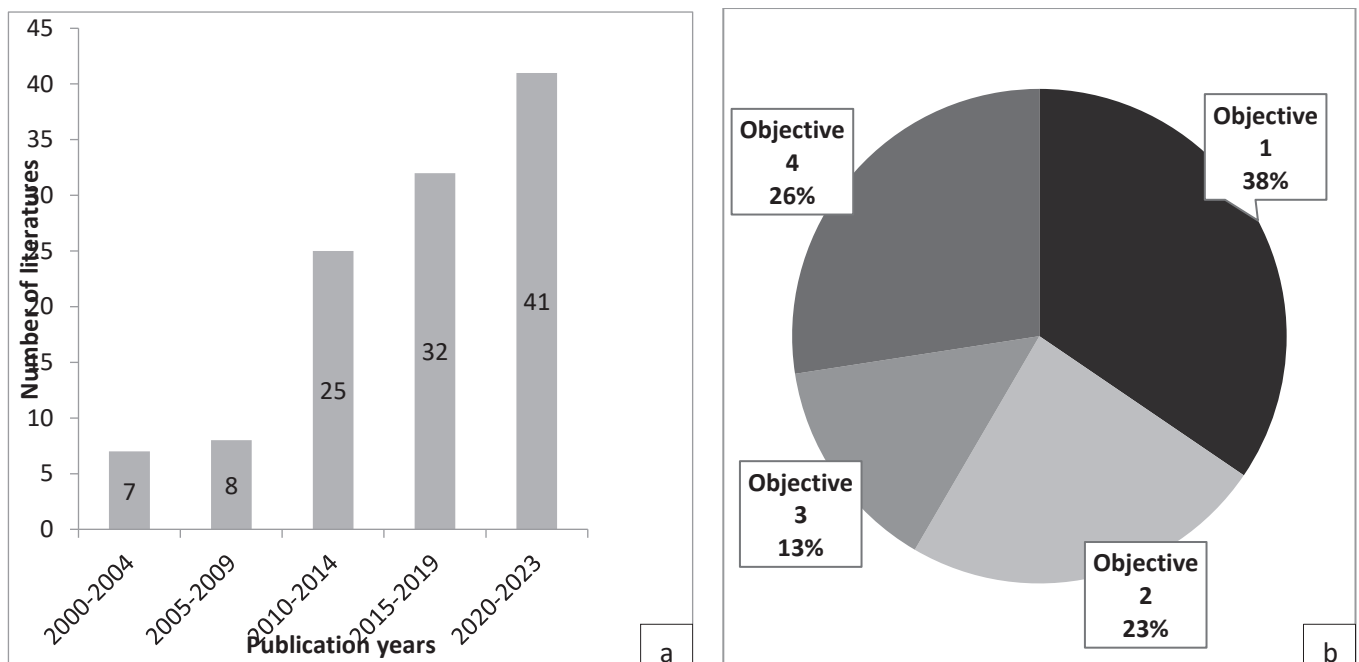


Figure 1. a) Number of papers published from 2000 to 2023; b) number of papers (presented in percentage) consulted per objectives of this review study.

3. Results and discussions

3.1. Drivers and processes of traditional gold mining practice

TGM is formal or informal and legal or illegal gold extraction carried out by individuals, families, and cooperatives working with no or very rare mechanization to excavate and process gold [28, 32-38]. Mercury is commonly used for the final gold amalgamation that can pollute the soil resource and the environment [39-43]. Poverty, unemployment, lack of knowledge, less appreciation of the natural resources by the miners and over ambitions

of the miners to get rich quickly are the prevalent causes of TGM practice [32, 44-47]. The traditional miners extract the gold mineral randomly using the trial-and-error method from the earth which might vary by type and source of deposits [14, 48-50]. The gold ore is mined from both the earth's surface and underground (subsurface) [34, 44, 51, 52].

3.2. Impacts of traditional gold mining practices on shrinkage of agricultural lands and soil quality

TGM terrains are often significantly altered and destructed from their former natural state [13, 53-55]. Mined areas remain with bare and rock-out crops and are left with embankments of waste tailings, shallow dugouts, and deep pits [52]. The mining practice leaves behind various land disturbances such as open pits, waste rock dumps, and tailings which are unworkable for agricultural purposes [6, 7, 56, 57]. Large pits, heaps of rock wastes, and tailings generated due to TGM activity led to the destruction of the natural landscape and loss of agricultural lands in the north-central parts of Nigeria [16, 58]. In Osun state, Nigeria [53] discovered about 354 mining pits as a major form of land degradation, and 25.8 ha of land was destructed in the entire mining site. Destruction of over 1000 hectares of suitable farmlands and flooding of abandoned pits has become a means of declining farmlands due to TGM practices in North Central Nigeria [59]. Considerable land areas in numerous mining areas of Ghana have been destructed to accommodate surface mining activities [56, 60-62]. In southwestern Ghana about 661.54 ha of agricultural land had declined from 1986 to 2006 due to TGM [61]. In the Western Region of Ghana, satellite-based analyses revealed that about 4,935 ha (25.5%) of farmland has been lost from 1986 to 2002 due to TGM [63]. Surprisingly, there is contrary research in the south and east regions of Cameroon [49] that argues TGM in the country indirectly increased farming sizes and agricultural products, particularly cash crops which intensified with income gained from mining.

Severe soil degradation due to arbitrary land destructions and removal of vegetation in the process of gold mining are the main impacts of TGM practices [7, 14, 16, 17, 46, 62, 64]. Extensive soil removal is the basic characteristic of TGM practices [4, 11, 65-67]. In Asgede-Tsimbla, northern Ethiopia, about 104,443 tons ha⁻¹ of soil material was lost due to TGM [4]. Soils of gold-mined areas in the western region of Ghana have low levels of nitrogen (N), phosphorus (P), and potassium (K) [68]. A similar study in the western part of Ghana found a lower content of soil N and P when compared to the natural forest [60]. A study in southwest, Nigeria reported that total soil N, available P, Ca²⁺, K⁺, Mg²⁺, Na⁺, and cation exchange capacities (CEC) have been significantly lower in areas disturbed by TGM practices than the unmined farmed lands [14]. TGM practice was the main cause of soil infertility as a result of the disappearance of the humus layer by the mining practice in Meiganga, Cameroon [69]. TGM practice is also profoundly witnessed in the entire surroundings of Amazon [7, 16, 51, 70] and causes severe impacts on soil resources [16, 71]. Widespread contamination of heavy metals from TGM is a major environmental concern due to their negative impact on soil and plant ecosystems [33, 39-42]. Cadmium, chromium, copper, mercury, lead, nickel, and zinc are some of the heavy metals that represent an effect of concern [13, 14, 40, 41, 43]. TGM operations could cause adverse effects on the soil ecosystem that in turn causes plant and human toxicities [7, 72] as the miners often use mercury amalgamation process to extract gold from ores. Heavy metals can be easily absorbed by plants and if such plants are eaten by man, they accumulate in the tissues and might lead to different health problems [73]. Surprisingly, there is a contrasting research finding in the Dunkwa East Municipality of Ghana "There were no significant differences ($p < 0.05$) in the concentrations of Cd, Hg, Pb, As, and Cu between the unmined and mined soils [74]. LiSome studies also argued that soil pH is relatively lower in the unmined sites (5.21) than that of mined environments (5.61) [22, 69]. Further study on the impacts of TGM on soil pH and concentration of heavy metals, therefore, urges to justify such inconsistent research outputs.

3.3. Impacts of traditional gold mining practices on vegetation cover and carbon stock

TGM practice destroys fundamental vegetation resources in the gold rush environments where the activity is dominantly practiced [3, 8, 64, 75-78]. Deforestation and forest degradation are amongst the most significant environmental impacts associated with TGM [10, 38, 79]. TGM in forest areas in Ghana resulted in irreversible deforestation and threatened the remaining forests through fragmentation and loss of biodiversity [8, 64, 68].

Gold mining activities in Nigeria also cause massive deforestation which has been responsible for the disappearance of the plant cover [69]. In the western region of Ghana, a satellite-based analysis inferred that about

3,168 ha of forests were cleared for gold mining pits between 1986 and 2002 within three areas (16.4% of the total mining areas) (Table 1) [63]. In the tropical moist forest of South America, around 680 km² of tropical moist forest was lost in 1600 potential gold mining sites between 2001 and 2013 [75]. Another research also indicated that in the Peruvian Amazon gold mining-related losses of forest averaged 4437 ha yr⁻¹ [70]. In Peru, TGM has degraded 90,000 ha of old-growth forest since the eighties leaving vast areas as wastelands [80]. TGM in Amazonia, therefore, resulted in adverse forest removal, and soil excavation, which together pose a major threat to biodiversity and forest carbon stocks. Fortunately, there is a contrary report from the Congo basin [81] that argues environmental impacts due to artisanal mining were temporary, low impact, and practiced on a limited scale. TGM practices threatened also the vegetation ecosystems of Ethiopia [82]. In Asgede-Tsimbla, northern Ethiopia plant species abundant and richness has been significantly smaller in the mined areas than in the nearby unmined areas [4]. Hence, there is an indication of TGM-induced degradation of landscapes and vegetation in Ethiopia. Tropical forests sequester important amounts of carbon but deforestation, and forest degradation continue to spread in most of the TGM sites and could release carbon to the atmosphere. In the Peruvian Amazon, aboveground carbon emissions from gold mining in 2017 and 2018 were 1.12 Tg C estimated from 750,000 hectares of forest destructed by gold mining [78]. TGM practice could, hence, be emissions-intensive sector [79] although studies are scarce on the comprehensive qualification of total organic carbon stocks considering aboveground and belowground organic carbon status of post-mined landscapes.

Table 1. Impacts TGM practices on vegetation cover

Site	Deforestation	%	Method of study	Study year	Source
Western Ghana	3,168 ha	16.4	Landsat satellite images	1986-2002	[63]
western Ghana	6053.4 ha	2.7	Landsat satellite images	1986-2016	[9]
Western amazon	100,000 ha	13.69	Landsat satellite images	1985-2017	[3]
South-western Ghana	14,820,000 ha	17.2	Landsat satellite images	1991-2016	[83]
Ijesaland, Nigeria	58,955 ha	23.52	Landsat satellite images	1986-2002	[53]

3.4. Impact of traditional gold mining practices on arbuscular mycorrhizal fungi communities

In most of the post-mined landscapes, there are changes in the microbial community abundance and diversity [84 - 86]. AMF is one of the ubiquitous soil microorganisms in nature and has great value and potential for ecological improvement [15]. However, disturbance of soil due to TGM could change the abundance and diversity of the AMF population [28]. Heavy metals and vegetation removal due to TGM decreased the diversity and abundance of AMF in an area affected by gold mining in Colombia [22]. The authors further noted that adverse soil properties of the mined tailings like Bulk density, alkaline pH, and low organic matter conditions, together with the concentration of heavy metals such as Chromium and Vanadium significantly affected the abundance of AMF in the gold mining sites of Colombia. A 3-year-old study of TGM in Indonesia noted that the conversion of natural forests into mining land contributed to a negative impact on AMF abundance and species richness [26]. Fortunately, various researchers noted that AMF species could tolerate the disturbed conditions apparent at artisanal mine sites [21, 27, 29-31].

3.5. Potential options for the restoration of degraded post-mined landscapes

Understanding traditional gold mining-driven soil mass movement and the associated geomorphic processes and the control of these processes is a fundamental prerequisite toward a successful restoration of mined sites. Hence, before re-vegetation of the post-mined sites, stabilizing the topography of mined sites to reverse the TGM-induced soil loss and creating a favored environment for plant growth in the mined-driven degraded land is a prerequisite post-mining restoration mechanism [45]. Certain practices, such as the backfilling of mined pits, top-soil conservation, and plantation of native species are crucial for effective restoration of gold mining sites [87].

Post-mined restoration, hence, includes the management of all types of physical, chemical, and biological disturbances of soils such as soil pH, fertility, microbial community, and various soil nutrient cycles that make the degraded land productive.

The plantation of selected native plant species could be a sustainable and organic tool for the restoration of post-mined land [45, 88, 89]. A native *Stylosanthes guianensis* cover crop in the TGM Amazonian Forest, Peru thrived in the degraded post-mined area [80]. One of the key factors for the success of post-mined degraded landscape reclamation with phytoremediation technology is, therefore, the use of local indigenous species [71, 89, 90, 91]. These indigenous species have well adapted to the soil and climate conditions of the host site and would ensure the greatest chance for remedial success [28]. A study in mining tailings of northwestern Mexico noted that the plantation of *R. communis* (native to the area) in the mined tailings showed that the concentration of potentially toxic elements (PTE) in above-ground organs significantly reduced by adding compost and nutrients to the growing substrate [71]. The occurrence of AMF in mined lands can promote plant growth by increasing nutrient absorption as well as protecting plants from the harmful effects of toxic metals [21, 30, 92, 93]. AMF species have the potential to restore degraded mined areas and developed as a bio-fertilizer for kalapi (an endangered endemic legume) cultivation in gold mine tailings of Sulawesi, Indonesia [30]. A study in Brazil noted that the recovery of forest structure and diversity on 40 post-mining restorations was associated with interactions between soil amendments and the establishment of plants [94]. In South Africa, Aloe plants showed potential for the phytoextraction and bioaccumulation of potentially toxic metals (PTMs) in contaminated soils from platinum and gold-mined tailings [95]. In the Ghanaian gold-mined tailings re-vegetated with Acacia species, soil physical characteristics such as bulk density, moisture holding capacity, and infiltration rates improved to levels comparable with the un-mined soils [96]. Post-mined restoration experiences approved that AMF-assisted ecological restoration of mined sites exhibits significant positive effects including increased plant survival, improved soil structure and quality, and greater plant re-establishment [31, 85, 97-99].

4. Conclusion and future perspectives

TGM practice leads to inevitable ecosystem degradation like shrinkage of agricultural lands, degradation of soil, vegetation, carbon stock, and beneficial microorganisms. In most of the post-mined landscapes, the size of agricultural lands had declined after TGM practices were experienced. However, due to the transient and unregulated nature of the TGM practice, the exact trends of farmland shrinkage due to TGM practice are not beyond the local research reports and urges for comprehensive current research. TGM practice causes severe deterioration of the soil physical, chemical, and biological properties making the soil resource unable to provide the crucial ecosystem functions. TGM practices are also the main source of potentially toxic elements. Most of the studies consulted in this review are, however, based on individual soil properties that lack integrated and comprehensive soil quality indicators and this could be a future research hotspot. Deforestation is the most common environmental impact derived from TGM practices. Although there is an indication of organic carbon stock declining associated with TGM, comprehensive research on the quantification of total organic carbon loss due to the TGM practice urges research. Several researchers proved that AMF could tolerate the extreme environmental conditions driven by TGM practice. Some researchers, however, argued that AMF could be affected by TGM-induced toxic elements. Considering the type of AMF and host plant species, such inconsistency inferences need further research. There are various research experiences concerning post-mined landscape restoration strategies. However, most of the research missed the incorporation of local communities' willingness in their restoration efforts.

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The principle of the Co-existence in Unification Thought and 'co-operative village': A case study of Song-ra village in the rural Korea in 1960s-1970s

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Abstract: This paper aims to revisit a model of the realization of the principle of the Co-existence in Unification Thought that emerged in Korean rural history through the example of a 'co-operative village.' A co-operative is a voluntary association created by citizens to co-operatively solve common needs in their lives. The Unification Thought's principle of co-existence has many similarities with co-operatives in that it seeks to realize an economy of true love that contributes to the welfare of all people from the perspective of the human family. This paper presents Song-ra Village in Icheon-si, Gyeonggi-do in the 1960s and 1970s as an example of a 'co-operative village.' Under the influence of the agricultural co-operative movement in the 1960s, the residents of Song-ra village established the 'Song-ra Agricultural Co-operative', and the businesses of the co-operative were established and operated such as village shop, a rice mill in the 1960s, a pumping station in the 1970s, a women's shop, a rice bank, a grain bank, a credit co-operative, a bale factory, and a Credit Union. This paper is significant in that it presents the possibility of realizing the Unification Thought's principle of Co-existence, an economic community of true love, at the local level through the example of a small-scale co-operative movement of villagers who pursued the common interests of the villagers.

Keywords: the principle of Co-existence, Unification Thought, co-operatives

1. Introduction

This study aims to explore the possibility of a 'village co-operative movement' as an example of realization of one of the core principles of the Unification Thought, 'co-existence'. It is known that the co-operative movement is closely related to religion. Throughout history, religion has had a profound influence on the growth of co-operatives [1]. For example, the Mondragon co-operative in Spain was founded by the Catholic Church, and it is well known that the Catholic Church was also heavily involved in Korea's credit co-operatives. American Sociologist Robert Putnam also explored the close relationship between social capital and religion [2]. On the other hand, co-operatives are often seen as a concrete way to realize religious ideals. Kyung Dong-hyun suggests the co-operative movement as a model for restoring religion's contribution to public life [3].

This study examines the principles of Unification Thought's co-existence' through the example of a 'village co-operative' in a case study of a rural Korean village in the 1960s. Through the example of co-operative businesses run by villagers in the case village of Song-ra Village, this study will explore how the principles of communitarianism were implemented in a village community and provide implications for future planning of communitarian communities where residents are 'co-existing'.

2. Materials and Methods

2.1 Literature Review

A co-operative is a self-governing, self-reliant, self-help economic organization that is formed to solve common economic needs that are difficult to meet through individual efforts through co-operation with neighbors [4].

Unlike ordinary businesses that exist for the benefit of a few investors, co-operatives are established to overcome the common needs of the people through the power of co-operation. Thus, they are in line with the spirit of 'co-existence', which defines the promotion of the welfare of all people as the ultimate purpose of economic activity.

Based on God's original ownership rights, Unification Thought aims for an economic community of true love that can contribute to the welfare of all people by claiming co-ownership of self and neighbor and appropriate ownership according to conscience [4]. The ideological characteristics of this philosophy can be summarized as follows.

First, it seeks joint ownership based on God's true love. It emphasizes not simply materialistic ownership, but the mental aspect behind the ownership, i.e., God's true love as the motivation for the possession [5]. According to Unification thought, God has endowed human beings with the right to have dominion over all things with love, and all human beings were to jointly possess the world with a heart of gratitude base on God's true love [5]. In this article, I define God's true love as selflessness, love for community members, and a desire to contribute to the well-being of community members, as found in the biblical commandment to love your neighbor as yourself.

Secondly, it advocates the harmony of joint and private ownership. So, to the question, 'Is there any private ownership in the ideal world?', the Unification Thought's answer is yes, there is private ownership in the ideal world. In the Unification Thought, private ownership is illustrated with case of joint family ownership, which is the prototype for various other joint ownerships. For example, family members live under the same roof, spending the same budget. Yet, each member of the family has his or her own unique individuality. Personal possession is necessary for them to accomplish their individual purpose. Private possession is necessary to accomplish the purpose for the individual, and at the same time, it is necessary to accomplish the purpose for the whole as well [5].

The third question is answering the question of 'to what extent is personal possession reasonable?' The appropriate possession-proper quality and quantity of each person's possession will be determined according to one's conscience. If our conscience is pure, God will show us through our conscience the psychological amount appropriate for our personal possessions. Thus, the appropriate possession of private property can be easily determined [5]. However, even though conscience determines the appropriate quantity and quality of each person's individual, the quantity and quality of their possession are not the same for all people. This is because all human beings are unique individuals with different personalities, and the second reason is that every person is an individual truth being and at the same time a connected being, the higher person might have more possession in other to give them to others [5].

2.2 Historical Background

In rural Korea, post-war agricultural policies were implemented to revive rural areas and alleviate poverty among farmers. In accordance with the government's policy, 'Ri-Dong agricultural co-operatives (hereafter village co-operatives)' were organized in most villages across the country following the establishment of General Agricultural Cooperatives in 1961. The General Agricultural Co-operative was initiated from above and therefore had limitations as 'farmers' organizations'; however, as an efficient basic organization for the implementation of national agricultural development policies, they were able to play an important function in the rural development policy of the developmentalist state [6]. As the final organization in the hierarchical organizational system of town and village-level agricultural cooperatives and the central agricultural cooperative association, the village co-operatives played a role in connecting farmers and the central agricultural cooperative association.

The rural villages where this movement was highly active were called 'co-operative villages. These 'co-operative villages' had co-operative businesses, which varied in number, type, and size from village to village, but were jointly established and operated by the residents. Running businesses to meet farmers' needs and raise funds for village development was a key strategy of the village co-operatives movement.

In the early 1960s, the village co-operatives were required to have common facilities such as marketplaces and rice mills to establish a business management system [7]. In addition to the co-operative movement, credit organizations such as credit co-operatives were developing in rural villages as a private sector movement to solve the problem of farmers' usury. These businesses were an important component of rural villages and an important component of rural villages and were the focal point for mobilizing villagers' capabilities.

2.3 Data and Methods

This paper used the 'Archival Document' method. The documents used are documents related to the Saemaul Movement in the 1960s and 70s held by the Saemaul Undong Central Training Center in Seongnam-si, Gyeonggi-do. The case area of this paper, Song-ra Village, Gyeong-gi-do, is one of 11 villages that donated their village data

to the Saemaul Undong Central Training Center. Song-ra Village data is a huge amount of 3,000 pages, and was selected not only because it is sufficient in quantity, but also because it contains a comprehensive collection of various types of documents such as meeting minutes, accounting books, loan documents, and official documents.

To compensate for the limitations of documentary sources, I conducted interviews with 9 villagers. The archives of Song-ra Village are sufficiently large and comprehensively categorized, which is useful for understanding the operations of village co-operative businesses. However, the documentation alone does not fully reflect the context in which the businesses were formed and operated and the experiences of the villagers involved in the entire process. In addition, village records are official records that are agreed upon and organized at the village level. Therefore, this researcher visited Song-ra Village between 2018 and 2020 and interviewed elderly villagers who participated in the village business in the 1960s and 70s, when the archives were produced.

3. Results

3.1. Co-ownership centered on God's true love

The Unification Thought says that even when people see their neighbors starving, they often do not seem to care, and just continue to live arrogantly; this is characteristic of capitalist society. They are basically living their lives against the Way of Heaven [5]. In terms of ownership, in capitalist economy there is private (individual) ownership while in socialist economy there is social (national) ownership. Yet, both economies the element of love is totally excluded [5]. In contrast, in the principle of mutual existence, joint ownership is based on God's true love. In other words, it is first, the joint ownership of God and myself; second, the joint ownership of the whole and myself; and third, the joint ownership of my neighbors and myself.

Song-ra Village, the research site of this thesis, is an example of 'village co-ownership'. In the harsh post-war environment, Korean farmers were suffering from poverty, and the co-operative movement was one of the many ways to address this poverty. When a co-operative business was established in Song-ra Village, it was motivated not by one's own well-being, but for the well-being of all the villagers. Co-operative businesses were established to meet the collective needs of residents and were operated by the village, with profits going into a common fund for village development. It can be termed as community ownership.

According to the village document, 'Youth in the village worked during the day and sat together at night to plan the village development'. In 1961, the first project of the village youth was establishing 'village market place'. Twelve village youths went to work on the construction of a dike and worked as laborer, carrying gravel on a forklift, and invested the money to build the first village cooperative business, 'village market place'. The purpose of this project was to collect a village common fund to solve the problem of poverty together. It is a very community-oriented and selfless act for young people to invest their own labor and funds to create a village common fund in the impoverished rural area represented by the expression 'Barley Hills'¹ in rural Korea.

This community-oriented motivation is further evident in the anecdote of youth leader Kim Kyung-yeol. He is a rural leader who has been active in the Icheon area since 1961, when he became the first youth leader of Song-ra Village. He promoted a plan to acquire a privately owned rice mill in the village with the village's common fund and turn it into a 'village rice mill'. At the time, the village's common fund was insufficient, so he travelled outside the village for more than seven months to solicit and obtain a loan to acquire the mill, and then called for a vote at the village meeting one day.

What happened at that village meeting shows the strong bond between Kim and the villagers. Kim's idea to take over the village's rice mill and make it communally owned was met with opposition from the villagers. 'How can the villagers run a rice mill together even two friends can't work together because they cannot cooperate?' they said. Shocked by this opposition, Kim fainted on the spot. Of course, it could be argued that Mr. Kim collapsed from disappointment that all his hard work had gone to waste. However, it also shows Kim's strong love for his neighbors, as he wants to help the whole village as if it were his own body.

Meanwhile, the villagers are worried about Mr. Kim's father, who may lose his 'only son in six generations' due to the incident, so they reverse their vote and decide to take over and run the rice mill as a community [16]. The success of the village's joint ownership and operation of the rice mill allows Song-ra Village to accumulate a large community fund and lays the foundation for the village's development in the 1970s.

This anecdote about the joint establishment of the 'village market place' and the 'village rice mill' shows that the villagers of Song-ra Village were motivated by the internal motivation of practicing true neighborly love and established a cooperative business owned by the village.

3.2. *Harmonizing co-ownership and individual ownership*

In Song-ra Village, individuals are allowed to own private property, and the good management of private property has become a prerequisite for the development of the entire village. Using the example of the water pumping station, one of the village businesses, I will discuss how the village communal business increased the productivity of individually owned rice paddies, and the well-cultivated rice paddies became a prerequisite for the cooperation of 'well-off individuals' for the development of the whole village.

It is worth noting that the "young cooperative activists" who established the marketplace and rice mills in Song-ra village in the early 1960s were also smallholder farmers.² They did not claim "common ownership" of the paddy fields, the main means of rice production. While they 'individually owned' the land, they jointly managed the water supply for production (pumping station), jointly enjoyed the services needed to process their products (rice mills, straw bag workshops), and jointly secured cash and in-kind resources to support their production and livelihoods (rice bank, grain, credit union). The profits from these communal businesses were saved as a 'village common fund' to be used to solve the common needs of the village. The common needs of the residents of Song-ra Village during this period were 'solving hunger through expansion of food production' and 'earning money to invest in their children's education'. During this period, the collective business and collective fund of Song-ra Village were used to solve these needs.

The Song-ra Village Water Pumping Station was established with investment from Icheon County in recognition of the villagers' ability to cooperate. In the late 1960s, Icheon-gun was looking for a village that could establish a water pumping station, but was unable to proceed because no village met two conditions: first, a village fund that could be self-supported, and second, a village organization with proven capabilities. However, village leader Kim Kyung-yeol wrote a 'memorandum' stating that the village could jointly operate the pumping station with village funds collected through the operation of a rice mill.

In 1970, a village business, water pumping station was established to help increase the productivity of privately owned rice fields. The pumping station provided a steady supply of water to residents who were "waiting for rain from the sky". There were much of hilly land in Song-ra Village, and there was not enough water for rice paddy causing chronic food shortages. The Song-ra Village Pumping Station pumped water from a nearby river with a motorized pump to supply agricultural water to the rice paddy. The pumping station contributed to increasing the productivity of the paddy fields owned by the residents, who were "smallholder farmers.

At the same time, in terms of labor, the labor of 'smallholders' who own rice fields contributed to the smooth operation of the pumping station, which is communally owned. The most distinctive feature of the Song-ra village pumping station is that the entire village population, not just the rice paddy owners, was mobilized and participated in the maintenance work. This 'mobilization' was not a forced mobilization by the village authorities, but rather a fulfillment of the villagers' obligations as villagers. Once a year, the day of watering the rice paddies was also the day of the village feast, when all the villagers worked together, cooked food, and shared it. The water pumping station in Song-ra Village was not an organization of the parties using the pumping station, as studies of community irrigation practices have shown [8]. It was a village-wide organization run by the village organization. In other words, all villagers, whether they were rice paddy holders or not, participated in the joint operation of the pumping station as co-owners of the village business.

The operation of the water pumping station in Song-ra Village is an example of the principle of co-existence, where communal and individual ownership are harmonized. While each villager cultivates his or her own private paddy fields, they cooperatively operate the common property of the water pumping station to equitably distribute the common resource of water, which in turn increases individual incomes. Strong individual property management contributed back to the management of village common property and village development.

3.3. *Appropriate Ownership according to individual conscience*

The Unification Thought's the principle of co-existence first advocates communal ownership based on God's true love, and second, individual ownership is permitted along with communal ownership. The third is the degree of individual ownership, which should be "appropriate ownership" according to the individual's conscience. In this chapter, we examine how this principle of "appropriate ownership" was applied to village businesses in Song-ra Village. According to the principle of co-existence, the proper quantity and quality will be determined according to one's own conscience [5].

How "appropriate ownership" was realized among the residents of Song-ra Village in the 1960s and 70s can be seen by looking at how loans and repayments from the village banks were made to cooperative businesses.

In Song-ra Village, loans and repayments at the village credit banks were based on the spirit of "neighborly love" to maintain the village community. The Unification Thought says that even when people see their neighbors starving, they often do not seem to care, and just continue to live arrogantly; this is characteristic of capitalist society. They are basically living their lives against the Way of Heaven [5]. In other words, owning enough to meet one's needs while considering the situation of one's neighbors is a life in accordance with Heavenly Way, or owning according to conscience.

First, let's take a look at how the communal village loan is distributed to individuals. The village loan fund was aimed at helping all the villagers cross the 'Barlry Hill', so it was operated according to the principle of one person, one straw bag of rice. In the 1970s, there were three village financial institutions operating in Song-ra Village: Grain Bank, Rice Bank, and a credit cooperative. The capital was raised through external support and investments of villagers, and loans were made and repaid on a one-year basis (one-year farming cycle). The village covenant states that 'members of the rice bank can search for and save up to five kilograms of white rice per member at their own discretion'. However, until the expansion of rice paddy and increasing of rice production brought the villagers out of food shortage, the implicit rule of 'one straw bag of rice per person' was followed.

Second, the loan limits of the village bank were set according to the circumstances of the villagers in order not to destroy the village community. In other words, there was no "loan sharking," the practice of lending beyond an individual's credit limit in pursuit of interest income of the bank. As the village began to recover from extreme food shortages, villagers began to borrow large amounts of village funds for their children's education and investment. As the village secretary gained experience over the years, he became familiar with the 'repayment capacity' of villagers and set loan limits accordingly. For example, if a person asks for 5 million won when their repayment capacity is 1 million won, the village secretary says no, and prevents them from borrowing more than their standard of living. The village secretary explained that the reason for this is that "if that villager gets it and that person can't pay it back aesthetically, it's a problem.

The village bank required loans to be repaid in one-year increments, in line with the farming cycle. If a villager borrowed too much and couldn't repay, he would lose his reputation and lose the trust of the community. In the worst-case scenario, the villagers would leave the village secretly. To prevent this from happening, the village secretary would grant loans according to the credit limits of the villagers he knew. This suggests that the operation of the village bank was based on neighborly love and community protection to contribute to the prosperity of its members and the maintenance of the community.

4. Conclusion

This paper aims to revisit a model of the realization of the principle of the Co-existence in Unification Thought that emerged in Korean rural history through the example of a 'co-operative village.' This paper present Song-ra Village in Icheon-si, Gyeonggi-do in the 1960s and 1970s as an example of a 'co-operative village', a community where the Principle of Co-existence is realized. The Song-ra village business, which was run by a village co-operative, is a great example of the principles of co-existence in action, as the principles of co-existence and co-operatives are similar in that they are based on love for community members and want to contribute to their well-being.

The ideological characteristics of the Principle of Co-existence can be summarized as follows. First, it seeks common ownership centered on God's true love. Secondly, it advocates the harmony of communal and individual ownership. Conscience-based private ownership means owning with love of neighbor and the maintenance of community in mind.

This paper explored how the principle of co-existence was realized in the example of the Song-ra Village cooperative business operation. First, the anecdote of the joint establishment of a village market place and a rice mill shows that the residents of Song-ra Village were internally motivated to establish a cooperative business owned

by the village as an act of true neighborly love. Second, the example of the operation of the water pumping station shows that the principle of co-existence, which is a harmonious combination of communal and individual ownership, is being realized in Song-ra Village. Third, Village lone was processed with the internal purpose of protecting neighbors and maintaining community.

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Towards a Culture of Gratitude

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Abstract: A heavenly (shin) world of co-existence, co-prosperity, and co-righteousness predicates a more elevated heart of compassion than during past history. Heaven's only begotten daughter and the Wang Omma (Great Mother) of humanity, Hak Ja Han Moon, has been using the Korean term *hyojeong*, or an attitude of filial heart to Heavenly Parent, to explain a core concept of the new culture of living for the sake of others in the Cheon Il Guk. She has elaborated on the need for gratitude. Recent psychological and neurological research on gratitude may be helpful to understand this enigmatic pivot towards heaven.

Keywords: gratitude, grateful, love, value, virtue, altruism, wisdom, thankful, Cheon Il Guk

1. Introduction

Gratitude is an ancient virtue esteemed around the world from African Yoruba tradition to the Bible, Qur'an, and Buddhist texts [1]. In 55 A.D., the Roman orator Cicero named gratitude not only the greatest virtue, but also "the parent of all the other virtues" [2]. Some individuals are blessed with a heart of gratitude, yet there may be billions of people who lack in gratitude and remain in a state of complaint and fear [3, 4].

Attempts to leave destructive cultural patterns through diligent practice of the Golden Rule [5] or True Parents philosophy to live for the sake of others are not sufficient [6, 7]. "Without a grateful heart," Wang Omma declared on 2013.02.10 at the Cheon Jeong Gung, Korea, "you cannot advance into the presence of Heaven" [8]. Psychological research assigns a central role to gratitude in developing traits like wisdom and altruism [9-12]. Other positive associations include life-satisfaction, health, making and strengthening friendship & marriage, positive affect (mood), prosocial and upstream reciprocity [13 - 14]. Personal gratitude is not fixed and can change. Training may increase gratitude, and research indicates that even short-term regiments can be effective [9].

2. Materials and Methods

2.1. A life of love predicates gratitude

The case was a 10-year-old girl. At the age of five years, she was diagnosed with B progenitor cell ALL. She got the first complete remission by multiagent chemotherapy. At the age of seven years, she completed chemotherapy while maintaining remission. At the age of nine years, she was diagnosed with the bone marrow recurrence of ALL. She got the second complete remission by multiagent chemotherapy. At the age of 10 years, she underwent allogeneic BMT from an HLA matched unrelated donor. She got engraftment and developed non-serious complications such as graft-versus-host disease and viral infection.

Three months after BMT, she developed bilateral pneumonia (Figures 1(a), 1(b)). Even with antibiotics, respiratory failure progressed rapidly, requiring mechanical ventilation 4 days after onset (Figure 1(c)) and extracorporeal membrane oxygenation (ECMO) 9 days later. The ECMO was continued for one month, but it would be difficult to continue any longer.

Neither Korean nor English contain suitable words to capture sublime states in the area of love, appreciation and gratitude. In the revelatory text "A Letter from God" to "My beloved True Parent," God states, "My beloved Son! My beloved Son! I, Jehovah, the God of all humankind, deeply love you and cherish you. Your heart is full of gratitude and thankfulness, yet My gratitude and appreciation for you is beyond words. The word "love" is inadequate to express My feelings, but no better word comes to mind" [15].

In the English text of Cheonbumo Gyeong (2015), the words "gratitude" or "grateful" appear sparingly, respectively 54 and 97 times, while the word "love" can be seen 2,209 times [16].

Father Sun Myung Moon explains, "Since you receive love, happiness, and hope from your object, you should be humble. Meekness is needed to accept these things." He concludes, "The secret of life is to be a good object" [17]. Or in the language of Dr. San Hun Lee, to have "object consciousness" [18]. Father Moon continues on the theme of gratitude, "We should always be grateful. First, we should be grateful to God, then to our husband or wife, then to our neighbors. The more gratitude you have, the deeper the love that flows into you. The more you share it, the more of God's love you will receive. You receive it in proportion to the gratitude you share" [19].

Speaking at the Belvedere Training Center, NY, on July 31, 1984, Wang Omma disclosed, "My motto in life is, 'How can I live today with more gratitude than yesterday?' I have tried to live a life in which I am more grateful today than I was yesterday, and in which I will be even more grateful tomorrow than I am today. It has been my life's goal to have gratitude in my heart every day." Her statement carried a somber tone as political intrigue and bias had caused her beloved husband to be incarcerated at the Federal Correctional Institution, Danbury, CT, on July 20 -- a mere eleven days earlier. She added that True Father encouraged all to be grateful as he left for Danbury. He had said, "Please never complain. You should be grateful for the position you have been placed in, for when you become completely one through your gratitude, great miracles can take place" [20].

2.2 Psychological views on gratitude

At <https://dictionary.apa.org/gratitude>, the American Psychological Association (APA) links gratitude to immediate and personally fortuitous events, such as suitable weather, receiving a gift or favor. Writing for APA, researchers Robert Emmons and Michael McCullough [21] defines gratitude as a recognition of "positive outcome" due to an "external source." They note that consciously focusing on gratitude may produce emotional and interpersonal serendipity not fully understood.

Gratitude has been likened to a moral barometer, indicating the moral level of the beneficiary, and as a moral thermostat that motivates the grateful person to direct or indirect reciprocation [22]. Describing gratitude from another angle, Abraham Tesser of the University of Georgia reports that the benefactor's intention, perceived cost, and value of benefit all independently influence the degree of gratitude [23].

2.3 Biological grounding of gratitude

A biological foundation for gratitude has been observed in a wide range of primates, fishes, birds and bats, according to a comprehensive whitepaper on "The Science of Gratitude," accessible at https://ggsc.berkeley.edu/images/uploads/GGSC-JTF_White_Paper-Gratitude-FINAL.pdf. Evolutionary biologist Robert Trivers [24] introduced the concept of reciprocal altruism to the discussion on gratitude in relation to mutually beneficial animal and human behaviors. During an interview at <https://www.scientificamerican.com/article/hdiden-logic-deception/>, Trivers also promoted the idea that self-deception and conflict play key roles in the neurological cost-benefit analysis in relation to altruistic behaviors. This is in line with ideas in popular press that self-interest calculations influence expressions of gratitude [25].

2.4 Neurological pathways

There have been successful attempts to use functional magnetic resonance imaging (fMRI) to link gratitude with specific neurological brain regions, such as the perigenual anterior cingulate cortex (pgACC) and gyral ACC [26-28]. Additional research indicates that oxytocin and possibly other neurotransmitters such as dopamine play key roles in gratitude formation [29]. However, still inconclusive is the search for a definitive neurological/facial/behavioral description of gratitude.

To determine whether altruism or self-interest are at the basis for charitable giving, Jason Hubbard at the University of Oregon [10] has been comparing fMRI scans of the pgACC, self-reported psychological evaluations of prosocial or altruistic tendencies and actual monetary donations. The three measures showed a strong positive correlation that a genuine, altruistic concern for others is at the basis of general benevolence. Of note is that general benevolence increases with age so that older persons are generally more benevolent than younger cohorts. Intentional practices such as gratitude journaling for a few weeks can increase benevolence. Prosocial interventions, such as taking financial action after viewing images of human suffering, can also change neural systems to support altruism [11-13]. Neurological changes include an increase of connectivity between the dorsolateral prefrontal cortex (DLPFC) and the reward center nucleus accumbens (NAcc).

Neuroscientist Christina Karns' longitudinal fMRI study of the ventromedial prefrontal cortex (VMPFC) indicate that pure altruism can be significantly cultivated in weeks [11]. Her team took care to isolate altruism through group action and to avoid influences such as warm fuzzy feelings from personal voluntary giving, prospect of reciprocity, or other specific social benefits from generosity. Their findings indicate that gratitude biases the brain's reward system toward others over oneself.

2.5 Modulators of gratitude

Philip Watkins of the Eastern Washington University has been analyzing what traits inhibit gratitude, such as suspiciousness, indebtedness, cynicism, envy and materialism. He proposes narcissism to be the "master inhibitor" that may interact with and enhance other gratitude inhibitors [30-31].

There are cultural influences that moderate experiences of gratitude. Kristen Layous and team [32] compared South Korean and U.S. college students. The South Korean students showed significantly less benefit than the U.S. cohort from writing gratitude letters. The self-reported effort in the interventions correlated with a greater increase in well-being among the U.S. participants compared with those from South Korea. Both groups were similar in regards to acts of kindness. Layous et al suggest this could be caused by the South Korean students experiencing more mixed emotions, such as indebtedness in addition to gratitude, through the letter writing activity as compared with their U.S. counterparts.

2.6 Some traits related to gratitude

There is remarkable positive association of gratitude to a number of sought-after traits, such as life-satisfaction [13] positive affect (mood), making and strengthening friendship & marriage [14] health, wisdom, prosocial and upstream reciprocity [9].

Austrian researchers Susanne König and Judith Glück [9] find strong links between gratitude and wisdom, especially those gleaned from difficult life experiences. They posit that wisdom and gratitude co-emerge as result of self-reflective integration. König and Glück also note that gratitude seems to accompany wisdom much more in women than in men.

There is a common thread in the world wisdom literature that encourages introspection. David Rosmarin and colleagues [33] conclude that religion may help people maintain gratitude even in the face of emotional distress. Especially supportive are religious community, prayer, meditation, and the process of re-framing negative events into opportunities for stronger internal connection to God. The research of Kraus, Desmond and Palmer [34] supports a strong positive association of gratitude with receiving answers from prayer and/or experiencing divine miracles. Furthermore, experiences of gratitude are ubiquitous and not tied to any specific faith, organization or cosmology.

3. Discussion

The preciousness of gratitude is like a diamond in the rough. As surveyed above, numerous desirable traits can develop from a life of gratitude, like improved mood and health, greater wisdom and altruistic behavior. A key feature is that a life of gratitude always recognizes the importance of others. Genuine gratitude can naturally move people towards a social life where the interactions are motivated by thankfulness and internal hearts yearning to do good for others. Interconnected through embraces of gratitude, humanity would then recognize the intrinsic value of others. When we also extend this awareness to our natural surroundings, appreciation and gratitude would automatically flow to its Creator, the ultimate cosmic and divine Parent.

For gratitude to develop, the public will need encouragement. Current online algorithms seem to promote old-fashioned power rivalry and disinformation, giving top listings and virtual reality training for war, economic trauma, shocking lawlessness and abhorrent verbal conflicts. However, there are some glimmers of hope. Those who search can find info on good deeds, excellence in sports, and beautiful service/assistance/arts/music-initiatives. Plus, ingenious ways to make simple and low cost person-to-person connections around the globe.

The determination to increase her own gratitude day by day was set by the Only Begotten Daughter, Mother Moon, years ago. Father Moon encourages all to be totally one with the miraculous power of gratitude regardless of circumstances. Taking their example as the nexus of modeling gratitude, next comes the task of increasingly larger groups of people to live lives of joyous gratitude. Families, tribes, peoples and nations are the building blocks to form a large interdependent world of gratitude and mutual prosperity.

While more research and testimonies are needed, a public awareness of the necessity of internal gratitude and clarifications on how such a heart can develop may well be an important aspect in developing the Cheon Il Guk, the world of filial heart to Heavenly Parent, all peoples and situations.

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Session 2

**Physical Science
for Co-Prosperity**

Theoretical Possibility of Developing a Spirit Communicator

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Abstract: Because humans are spiritual beings, they are natural spirit communicators. Especially, mediums are believed to be able to communicate with deceased people in the spirit world or even God. If the physical structure of humans is something special that enables such spiritual communication, any spirit may be able to possess a cloned human body without its own spirit self, which allows exchanges of information between the physical and spirit worlds. Such spiritual activities in human brains can be monitored through brain waves using appropriate instruments, and possibly send signals back to the spirit world through human brains. It presupposes electromagnetic waves contain spiritual information at some frequencies or in the way they deviate from supposedly random white noise. Quantum physics introduced a new philosophy that observable phenomena can only be explained by assuming the existence of unobservable quantities expressed using imaginary numbers. Those unobservable quantities may exist in another set of dimensions exist that interact with the observable dimensions. Quantum computers utilize such quantum phenomena before they converge into macroscopic binary states. Therefore, using a quantum computer may allow interacting with the other dimensions, such as exchanging emails with deceased people in the spirit world or people who are still alive in the physical world.

Keywords: spirit communicator, medium, brain wave, quantum physics, quantum computer

1. Introduction

The desire to communicate with the dead or other spiritual beings such as angels and beyond has been consistently strong among inventors including Thomas A. Edison who actually announced in 1920 that he was working on developing a spirit phone [1] although no material evidence of even the prototype was found.

Now that a century has passed since then, there are still people working on developing a spirit communicator such as SoulPhone [2]. While many people seem to believe the existence of souls and life after physical death as spiritual human beings, the possibility of developing a physical device that can communicate with the spirit world is not recognized as common knowledge. In this paper, the theoretical possibility of developing such a spirit communicator is explored from circumstantial evidence and modern science.

2. Evidence of interactions between spiritual and physical matters

2.1. Mediums

Assuming that there are true mediums, the fact that mediums can hear or even see spirits or that spirits can influence medium's body indicates that spiritual beings can interact with physical matters including human brains. Because human brains are made of cells made of molecules made of atoms made of basic particles, such interactions with spiritual beings can be in the realm of the smallest basic particle level.

For example, when a medium sees a spirit, the spirit may interact with the spiritual dimension of photons which form an image on the physical eyes of the medium through photon-electron interactions, or the spirit may be acting on electrons of the medium's optic nerve to form the image. When the medium hears the voice of a spirit, the spirit may also be acting on electrons of the medium's auditory nerve.

2.2. Extrasensory perception (ESP)

There are people (ESPer) who have special capability beyond normal physical skills. Although bending spoons once became a well-known skill many years ago, there are many other skills such as remote viewing, telepathy, precognition, and psychokinesis. Because there is no clear physics known to perform these actions, their psychic powers must be using another dimension than the four-dimensional space-time.

2.3. True dreams

Including the author, there are many people having a dream that came true. I had a planned outing with one of my friends but had a dream the night before that planned date where he said he would not be able to go, which came true. I also used to be able to wake up in the morning only tens of seconds before the time my alarm clock was set to ring. These experiences suggest that one’s spirit self can interact with someone else’s spirit self even while their bodies are sleeping apart from each other, or the spirit self can check time by looking at the clock. Out-of-body experiences are also similar to these phenomena.

2.4. Ghost photos and videos

Even ordinary people who are not mediums are reported to have taken photos and videos of ghosts. ESPers can also perform psychic photography. These facts indicate again that photons and electrons can interact with spiritual forces if psychic power utilizes one’s spirit.

3. Theoretical background of spiritual and physical interactions

Evidences listed up in the previous section overwhelmingly point to the concept that even the smallest basic particles such as electrons composing both human bodies and other matters can interact with another dimension called the spirit world. Over the last century, quantum physics revolutionized classical physics, entire science including cosmology, and even philosophy. Depicted in Fig. 1 is so-called the double-slit experiment [3], which can illustrate the basic concept of quantum physics.

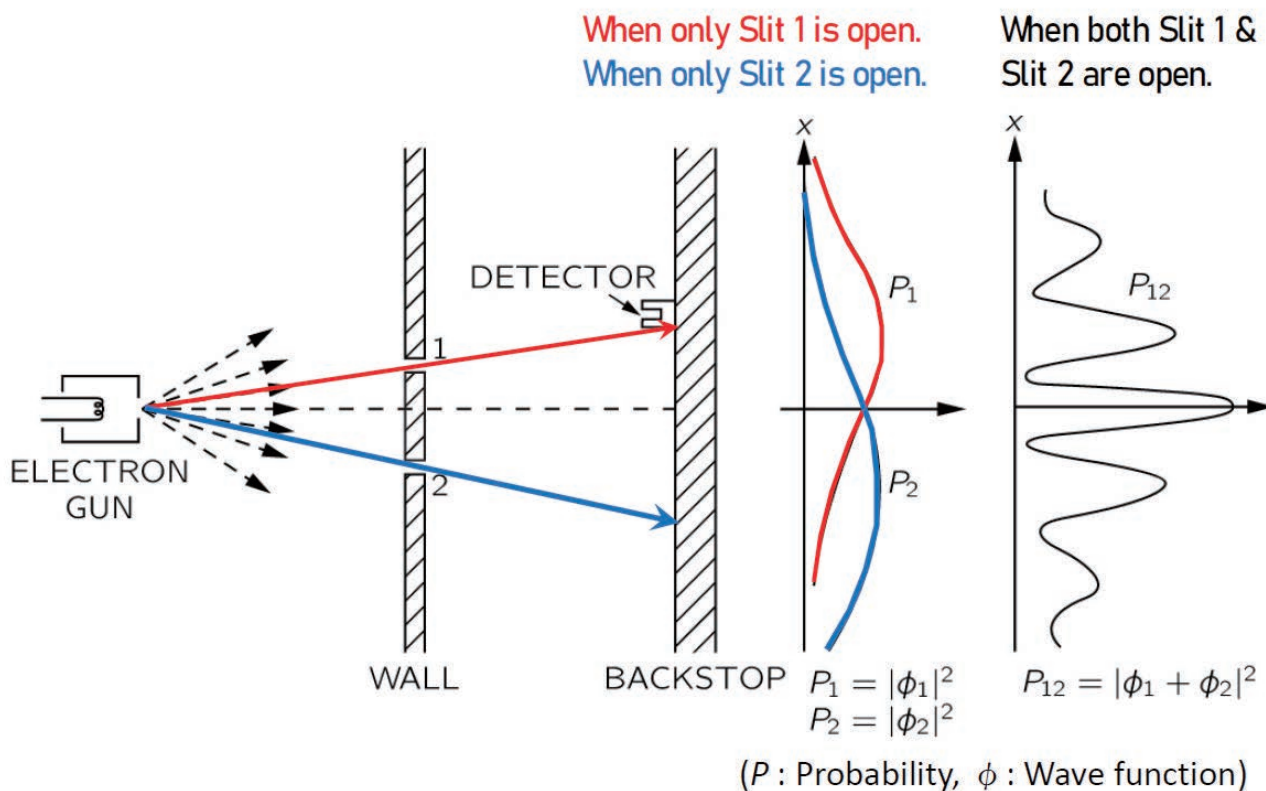


Figure 1. Explanation of double-slit experiments with electrons according to quantum physics.

Each electron has a wave function that is expressed in both real and imaginary numbers (complex number) and interacts with other objects or forces in the complex number space. If only one of the slits is open, there is only one path, and the resulting probability distribution along the backstop becomes identical to the result by classical physics. However, if both slits are open, each electron interacts with itself among its possible paths which is through either Slit 1 or Slit 2 in the complex number space, and when it hits a detector on the backstop, square

of the absolute value of the wave function (superposition of two wave functions) is observed which shows the result of self-interference as a wavy shape.

What this theory claims is that another dimension expressed in imaginary numbers is necessary to express the observed four-dimensional world expressed in real numbers. This is highly similar to what religions teach, that is God's power and prayers can influence phenomena occurring in the physical world. In order to allow basic particles such as photons and electrons to interact with the spirit world, each of them must have spiritual dimensions, which means that basic particles and the entire physical world are inside the spirit world, and both of them came from the world of the First Cause, or religiously speaking, God as shown in Fig. 2.

The physical world consists of at least four dimensions of three spatial dimensions and time. If human beings are to live in a similar same manner in the spirit world as they do in the physical world, the spirit world should also consist of three spatial dimensions and shared time. And if God created these two worlds as causal beings, God's world should also consist of three dimensions and shared time. Shared time is necessary if God and spiritual and physical people are to interact with one another in real time.

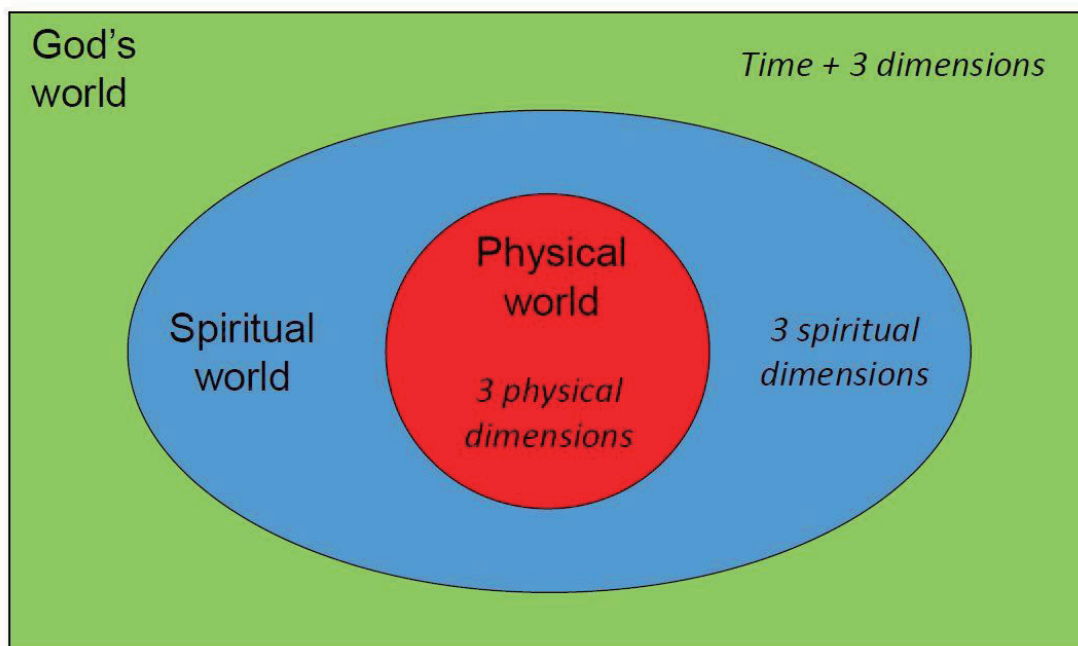


Figure 2. Possible relationship among physical, spiritual, and God's worlds and their number of dimensions.

4. Conclusion

Because even the most fundamental basic particles can interact with the spirit world, a special device made of them and constructed in a certain way should be able to replicate the spiritual capability of human bodies that can interact with spiritual beings.

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Electron Model as a Spherical Standing Wave: Validation by Constant Calculation

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Abstract: Positivity and negativity, particle and wave nature are fundamental properties in existence. Assuming the existence of a complex point charge with these properties, a spherical standing wave model is derived. This spherical standing wave is a spherically symmetric standing wave that resonates between the inner and outer radii. The inner radius does not become zero; therefore, no self-energy divergence problem exists. Since it has complex amplitude corresponding to voltage (scalar potential) and current (vector potential), it is compatible with quantum theory that also has complex amplitude. An electron model is assumed to be a spherical standing wave with an electron classical radius as the inner radius, a Bohr radius as the outer radius, and an elementary charge as the size of wave source. This study obtains energy and resonance conditions from an equivalent resonance circuit. The derived formulas include the Compton wavelength, electron mass, ionization energy, and Rydberg constant. Thus, the calculated values were consistent with existing physical constants. Bohr's atomic model introduced a special assumption of quantum conditions instead of explaining why circularly moving electrons do not emit electromagnetic waves. Conversely, no special assumptions are necessary for the spherical standing wave model, wherein the range of existence of the wave is determined through the resonance conditions.

Keywords: spherical wave, complex amplitude, Bohr radius, electron classical radius, fine structure constant, Compton wavelength, electron mass, ionization energy, principal quantum number, Rydberg constant

1. Introduction

A sphere is among the most fundamental forms found in nature. Therefore, spherical waves are more appropriate than plane waves when considering waves inherent in nature or those that resonate with it. Electrons are not only representative of point charges but they also exist with waves. Electrons as point charges suffer from the self-energy divergence problem at the center [1]. Milo Wolff proposed a spherical standing wave with the form $e^{i\omega t} \sin kr/r$ as an electron model by subtracting the outward spherical wave from the inward spherical wave. The amplitude becomes finite when $r = 0$ [2-4].

The spherical standing wave proposed herein is a spherical wave (outward or inward) with a complex amplitude. It has two types of standing waves inside, namely, pressure and flow [5]. The inner and outer radii are determined by the resonance condition, and an important feature here is that waves exist only between them. The inner and outer radii, frequency (wave number), and energy have a close relationship defining other parameters with respect to each other [6]. The inner radius does not become zero; therefore, no self-energy divergence problem exists. When a spherical standing wave is postulated as the electron model, we consider its consistency with various parameters derived from conventional quantum mechanics. This paper was revised as a technical report of a previous study [7].

2. Fundamental wave of the spherical standing waves

The scalar field $\phi(r, t)$, wherein the distance from the center is r and the time variable is t , can express the scalar potential ϕ of a spherical wave as follows:

$$\phi(r, t) = \frac{q_0 e^{i(\omega t \mp kr)}}{4\pi\epsilon_0 r}, \quad (1)$$

where i is the imaginary unit; e is the base of the natural logarithm; ϵ_0 is the vacuum permittivity; ω is the angular frequency representing the temporal phase; and k is the wave number representing the spatial phase.

The spherical wave amplitude is inversely proportional to the distance r from the center. The equivalent of the proportionality constant is the amplitude coefficient q_0 , i.e., q_0 is a constant representing the size of the spherical wave source.

However, the scalar field in Eq. (1) is also the sum of the phase potential added to the electrostatic potential created by charge q_0 . In the phase term $e^{i(\omega t - kr)}$, the iso-phase surface moves along the direction in which the radius r increases with time t . Therefore, it represents an outwardly directed spherical wave. Similarly, the phase term $e^{i(\omega t + kr)}$ represents an inwardly directed spherical wave and may also be regarded as the delayed (or advanced) potential of charge variation with respect to time $q = q_0 e^{i\omega t}$.

The angular frequency ω representing the temporal phase and the wave number k representing the spatial phase are related by $\omega = kc$. The constant c is a constant representing the speed at which the wave propagates. In the case of electromagnetic waves, it is generally a constant representing the speed of light.

According to the exact solution of the Maxwell equation for a spherical wave, the current and displacement current in a spherically symmetric spherical wave are in opposite directions with respect to one another and no magnetic field is generated [8]. Moreover, from a wave perspective, a spherical wave with a complex amplitude can be identically deformed as shown in Eq. (2). The inner portion of the wave shows that it comprises a voltage standing wave and a standing wave corresponding to the current [5].

$$\phi(r, t) = \frac{q_0 e^{i\omega t}}{4\pi\epsilon_0 r} \cos kr + \frac{q_0 e^{i(\omega t \mp \pi/2)}}{4\pi\epsilon_0 r} \sin kr. \tag{2}$$

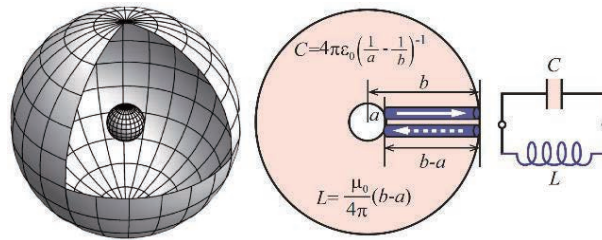


Figure 1. A circuit equivalent to a concentric spherical cavity resonator. a : inner radius; b : outer radius; C : capacitance of spherical capacitor; L : inductance of linear coil.

2.1. Energy and resonance conditions of the spherical standing wave

Consider a concentric spherical cavity surrounded by radii a and b ($a < b$) (Fig. 1). The energy density is expressed as follows [6]:

$$\frac{\epsilon_0}{2} (\nabla\phi) \cdot (\nabla\phi^*) = \frac{q_0^2}{32\pi^2\epsilon_0} \left(\frac{1}{r^4} + \frac{k^2}{r^2} \right), \tag{3}$$

where ϕ^* is the complex conjugate of ϕ . The total energy U is obtained by computing the definite integral on the spherical shell $4\pi r^2 dr$ of the section in which the wave exists $[a, b]$.

$$U = \int_a^b \frac{\epsilon_0}{2} (\nabla\phi) \cdot (\nabla\phi^*) 4\pi r^2 dr = \frac{q_0^2}{8\pi\epsilon_0} \left(\frac{1}{a} - \frac{1}{b} \right) + \frac{q_0^2}{8\pi\epsilon_0} k^2 (b - a). \tag{4}$$

We obtained the following using the $1/c^2 = \epsilon_0\mu_0$ relation:

$$U = \frac{q_0^2}{8\pi\epsilon_0} \left(\frac{1}{a} - \frac{1}{b} \right) + \frac{\mu_0}{8\pi} q_0^2 k^2 c^2 (b - a). \tag{5}$$

The first term on the right-hand side of Eq. (5) is equivalent to the electrical energy $q_0^2/2C$ when the charge q_0 is stored in a capacitor of capacitance $C = 4\pi\epsilon_0(1/a - 1/b)^{-1}$. The second term on the right side of Eq. (5) is equivalent to the current energy $L(\omega q_0)^2/2$ when a current $\omega q_0 (= kcq_0)$ flows through a coil with inductance $L = (\mu_0/4\pi)(a - b)$. In a resonance state, if both energies are observed to be equal, then

$$k^2 ab = 1, \tag{6}$$

and the resonance conditions are obtained [6].

3. Application to electron model

Consider the spherical standing wave as an electron model. First, let the magnitude of the spherical standing wave source be the elementary charge q_e , inner radius a be the electronic classical radius r_e , and outer radius b be the Bohr radius a_0 .

$$r_e = \frac{q_e^2}{4\pi\epsilon_0 m_e c^2} \Rightarrow a, \quad a_0 = \frac{4\pi\epsilon_0 \hbar^2}{m_e q_e^2} \Rightarrow b. \quad (7)$$

Moreover, the fine structure constant [9] is expressed as $\alpha = q_e^2/4\pi\epsilon_0 \hbar c$, Henceforth, the expression

$$a = \alpha^2 b, \quad (8)$$

will be used for the relationship obtained. In this paper, the inner radius a and outer radius b represent the classical electron radius and Bohr radius, respectively.

From Eqs. (6) and (8), the wave number k is obtained as

$$k = \frac{1}{\sqrt{ab}} = \frac{1}{\alpha b}. \quad (9)$$

When the wavelength corresponding to this wave number k is calculated, it matches the Compton wavelength of the electron.

3.1. Total energy and mass of the electron

From Eqs. (5) and (8), the total electron energy U is given as

$$U = \frac{q_e^2}{8\pi\epsilon_0} \cdot \frac{1}{a} (1 - \alpha^2) + \frac{\mu_0}{8\pi} q_e^2 k^2 c^2 b (1 - \alpha^2). \quad (10)$$

When the resonance condition $k^2 ab = 1$ is satisfied, the electrical and current energies become equal and may be expressed as

$$U = \frac{\mu_0}{4\pi} q_e^2 k^2 c^2 b (1 - \alpha^2). \quad (11)$$

From the equivalence of energy and mass, mass m is expressed as

$$m = \frac{U}{c^2} = \frac{\mu_0}{4\pi} q_e^2 k^2 b (1 - \alpha^2). \quad (12)$$

When this mass is calculated, it matches the existing electron mass within the range of four significant figures.

Although they are essentially in agreement, the electron model value is slightly smaller than the existing electron mass by approximately 0.005%. The fine structure constant is usually called the electromagnetic interaction coupling constant. Assuming that the term proportional to α^2 is the energy required for the interaction, the mass, m' , can be expressed as

$$m' = \frac{\mu_0}{4\pi} q_e^2 k^2 b. \quad (13)$$

When the mass, m' , is calculated, it matches the existing physical constant, electron mass [10].

This is probably because the existing electron mass is based not on the zero energy, but rather on the energy (mass) of the interactable state. The energy U' corresponding to mass m' is obtained by omitting the term proportional to α^2 in Eq. (10):

$$U' = \frac{q_e^2}{8\pi\epsilon_0} \cdot \frac{1}{a} + \frac{\mu_0}{8\pi} q_e^2 k^2 c^2 b. \quad (14)$$

3.2. Ground-state electronic model

In the energy calculation for the spherical standing wave in Eq. (4), we consider the case where the wave is only between the radii a and b . Figure 2 shows the model in that state.

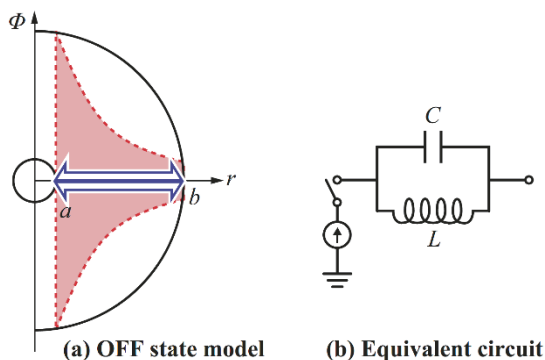


Figure 2. OFF-state electron model. The pale red (gray) area shows the voltage amplitude. The arrow on the horizontal axis depicts the current range (displacement current in the direction opposite to the current direction).

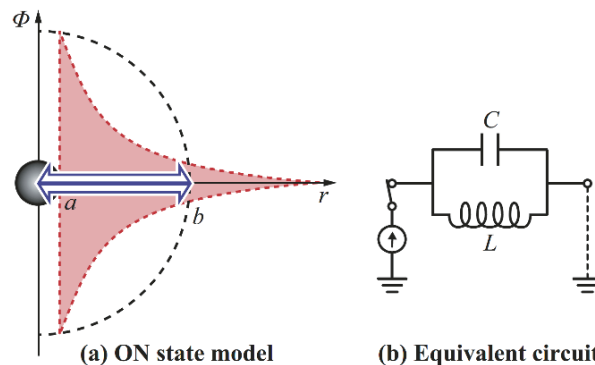


Figure 3. ON-state electron model. The switch of the current source is closed. The voltage amplitude exists from a to infinity. The current exists from 0 to b .

An LC circuit as an equivalent circuit, if it is connected to an external circuit, can be considered as an LC parallel circuit. In such an LC parallel circuit, the impedance seen from the outside takes the maximum value at the time of resonance. The existence of a wave source (current source) is implicitly assumed to be at the center of the spherical wave, but at resonance, the switch with that current source can be considered open. Thus, this state is called the OFF state and considered to be the so-called “zero energy state.” It is the lowest in energy and represents the ground state of an electron.

3.3. Electron model of the ionic state

When considering the existence of electrons as a cause of phenomena, such as static electricity, the spatial range of the existence of the electrical field created by the charge of the electrons is thought to have spread to some extent.

Equation (5), which represents the energy of a spherical standing wave, is the sum of the electrical and current energies. Electrical energy greatly depends on the inner radius a , and the effect of the outer radius b is small. Conversely, the current energy greatly depends on the outer radius b , while the effect of the inner radius a is small. The energy U' in Eq. (14) is obtained by calculating the electrical energy up to $b = \infty$. The current energy corresponds to that calculated from $a = 0$.

Therefore, consider the case where an electric field, such as static electricity, is generated outside the outer radius b of the spherical standing wave (Fig. 3(a)). This is a case where a quasi-electrostatic wave has no current component, i.e., without movement of the equi-phase plane. However, the resonance condition does not change and has the same wave number k . Here, the same amount of current energy as the increased electric energy must be generated. This dual current energy is thought to broaden the range of existence from the inner radius a to the origin 0 (Fig. 3). Thus, the switch between the current source and the equivalent circuit is considered to be in the closed state, and the state is called the ON state.

In the OFF state, the outer radius b becomes a discontinuous surface of the electric field, and it appears as if a surface charge is generated there. Conversely, in the ON state, the outer radius b is no longer a discontinuous surface of the electric field and the surface charge generated in the OFF state appears as if it has moved to infinity. In chemistry, this ON state is considered to be an “ionized state,” which is said to be a state wherein “+ ions and electrons are lost.”

3.4. Total energy of the ionic state

The energy U' in Eq. (14) is thought to be the total energy of the ionic state. The energy density that generates this energy is expressed as

$$\frac{\epsilon_0}{2} (\nabla\phi) \cdot (\nabla\phi^*) = \frac{q_e^2}{32\pi^2\epsilon_0} \times \begin{cases} k^2/r^2 & [0, a] \\ \frac{1}{r^4} + \frac{k^2}{r^2} & [a, b] \\ 1/r^4 & [b, \infty] \end{cases} \quad (15)$$

However, there is not one potential candidate that can produce such an energy density. For example, in terms of the electric field generated outside the outer radius b , the electrostatic potential $q_e/4\pi\epsilon_0 r$ generated by the charge q_e is one of the candidates from the viewpoint of energy only. From the wave continuity, the potential $q_e e^{i\omega t}/4\pi\epsilon_0 r$ that does not involve the equi-phase plane movement in the r direction, but changes the phase in time is a promising candidate.

The electric energy U'_e in the interval $[a, \infty]$ and the current energy U'_i in the interval $[0, b]$ are expressed as

$$U'_e = \frac{q_e^2}{32\pi^2\epsilon_0} \int_a^\infty \left(\frac{1}{r^4}\right) 4\pi r^2 dr = \frac{q_e^2}{8\pi\epsilon_0} \cdot \frac{1}{a}, \quad (16)$$

$$U'_i = \frac{q_e^2}{32\pi^2\epsilon_0} \int_0^b \left(\frac{k^2}{r^4}\right) 4\pi r^2 dr = \frac{q_e^2}{8\pi\epsilon_0} k^2 b. \quad (17)$$

Equations (16) and (17) present the maximum values of the electrical and current energies, respectively. When $k^2 ab = 1$ satisfies the resonance condition in Eq. (6), the two are equal, and their sum is equal to the total energy U' in Eq. (14).

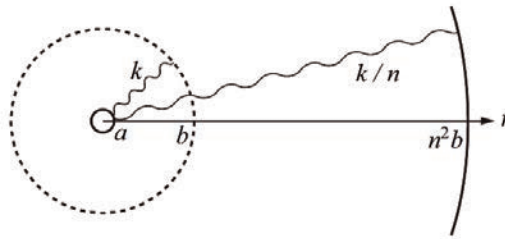


Figure 4. Outer radius and wave number after transition. n is the natural number. When the wave number changes from k to k/n , the outer radius changes from b to n^2b .

3.5. Resonance conditions and state transition

Consider the case where the basic parameters of a spherical standing wave, wave number k , inner radius a , and outer radius b change due to transition. After transition, let k' be the wave number, a' the inner radius, and b' the outer radius. The resonance condition after transition is maintained:

$$k'^2 a' b' = 1, \quad (18)$$

where n is a natural number and wave number k' is the case where the original wave number k is divided by n . Assuming that the inner radius $a' = a$ remains unchanged, the outer radius after transition $b' = n^2b$ is given by Eqs. (6) and (18) [11]. Figure 4 shows the relationship between the outer radius and wave number after the transition. This transition is called the n state.

The electrical energy $U_e(n)$ and current energy $U_i(n)$ in section $[a, n^2b]$ transitioning to the n state are as

$$U_e(n) = \frac{q_e^2}{32\pi^2\epsilon_0} \int_a^{n^2b} \left(\frac{1}{r^4}\right) 4\pi r^2 dr = \frac{q_e^2}{8\pi\epsilon_0} \left(\frac{1}{a} - \frac{1}{n^2b}\right), \quad (19)$$

$$U_i(n) = \frac{q_e^2}{32\pi^2\epsilon_0} \int_a^{n^2b} \left(\frac{k^2}{r^4}\right) 4\pi r^2 dr = \frac{q_e^2}{8\pi\epsilon_0} \cdot \frac{k^2}{n^2} (n^2b - a). \quad (20)$$

In the n state, the wave range extends to n^2b ; however, the wave only exists in interval $[a, n^2b]$; therefore, it is equivalent to the energy in the OFF state as in the case in Fig. 2.

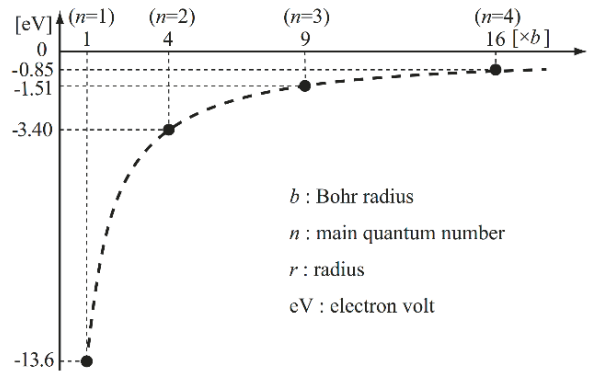


Figure 5. Principal quantum number dependence of ionization energy. The horizontal axis represents the distance from the center, while the vertical axis represents the energy in electron volts [eV].

3.6. Principal quantum number dependence of the ionization energy

Consider the ON state further after transition to n state. This state is considered to be ionization in n state. If the electric energy in this case is $U'_e(n)$, it is equal to the maximum value U'_e of the electric energy in Eq. (16) because the electric energy exists in section $[a, \infty]$.

The energy difference between the ON and OFF states in the n state is expressed as

$$U_e(n) - U'_e = -\frac{q_e^2}{8\pi\epsilon_0} \cdot \frac{1}{n^2 b}. \quad (21)$$

This equation demonstrates the principal quantum number dependence of the ionization energy of electrons. Moreover, Eq. (21) divided by q_e provides the ionization energy in electron volts. Fig. 5 shows the dependence of the ionization energy on the principal quantum number [12]. The energy takes a negative value because it is based on the maximum value of the electrical energy U'_e .

3.7. Derivation of the Rydberg constant

Let n and m be natural numbers (where $n > m$) and determine the difference in electrical energy when transitioning from the n state to the m state.

$$U_e(n) - U_e(m) = \frac{q_e^2}{8\pi\epsilon_0 b} \left(\frac{1}{m^2} - \frac{1}{n^2} \right). \quad (22)$$

Think of this as the energy of the emitted light. If the angular frequency of light is ω_{nm} and the Planck constant is $\hbar = h/2\pi$, the photon energy equals $\hbar\omega_{nm}$. Using the relationship of $\omega_{nm} = 2\pi c/\lambda_{nm}$ and expressing it as the reciprocal of the wavelength, λ_{nm} ,

$$\frac{1}{\lambda_{nm}} = R_\infty \left(\frac{1}{m^2} - \frac{1}{n^2} \right), \quad R_\infty = \frac{q_e^2}{16\pi^2\epsilon_0 b \hbar c}, \quad (23)$$

and an equation representing the so-called spectral series of hydrogen atoms is derived. Here, R_∞ represents the Rydberg constant (Bohr radius is represented by b) [9]. Additionally, using the fine structure constant, $\alpha = q_e^2/4\pi\epsilon_0\hbar c$,

$$R_\infty = \frac{\alpha}{4\pi b}, \quad (24)$$

can be expressed. Moreover, the light is absorbed if $n < m$.

4. Conclusions

Table 1 shows the correspondence with the Bohr model [13]. Table 2 shows the calculation formulas and values of the model in this study. The values were calculated to 11 significant figures using the 2018 CODATA recommended values [14]. All the digits matched the existing physical constants.

Table 1. Comparison between the Bohr and spherical standing wave models

Electron (Bohr model)	Spherical standing waves
Elementary charge	Wave source size
Bohr radius	Outer radius
Classical electron radius	Inner radius
Compton wavelength	Wavelength
Mass	Total energy / c^2
Quantum condition	Resonance condition
Spin (up/down)	(Outward/inward) spherical wave

Table 2. Expression and calculated values using the spherical standing wave model

a : classical electron radius; b : Bohr radius; α : fine structure constant; q_e : elementary charge

	Expression	Calculated values
Wave number	$k = 1/\sqrt{ab} = 1/\alpha b$	$2.589\ 605\ 0748 \times 10^{12} \text{ m}^{-1}$
(Compton) Wavelength	$\lambda = 2\pi\sqrt{ab} = 2\pi\alpha b$	$2.426\ 310\ 2387 \times 10^{-12} \text{ m}$
Mass (ground)	$m = \frac{\mu_0}{4\pi} q_e^2 k^2 b (1 - \alpha^2)$	$9.108\ 898\ 6145 \times 10^{-31} \text{ kg}$
Mass (excited)	$m' = \frac{\mu_0}{4\pi} q_e^2 k^2 b$	$9.109\ 383\ 7015 \times 10^{-31} \text{ kg}$
Ionization energy	$-\frac{q_e}{8\pi\epsilon_0} \cdot \frac{1}{n^2 b}$	$-13.605\ 693\ 123 \text{ n}^{-2} \text{ eV}$
Rydberg constant	$R_\infty = \frac{\alpha}{4\pi b}$	$1.097\ 373\ 1568 \times 10^7 \text{ m}^{-1}$

Bohr's atomic model introduced a special assumption of quantum conditions instead of explaining why circularly moving electrons do not emit electromagnetic waves. Conversely, no special assumptions are necessary for the spherical standing wave model, wherein the range of existence of the wave is determined through the resonance conditions.

The mass of an electron can be accurately calculated, and this mass is a physical quantity that changes depending on the energy state. The self-energy divergence problem of point electrons has been solved without using renormalization [15].

Herein, we presented two types of excited states. The ionization energy is generated by the energy difference between the ON and OFF states without a wave number change. The light energy generates the difference through the transition states with a wave number change. Ion and light energies are calculated as the differences in the electrical energy between the states. However, simultaneously, the same amount of change in the current energy occurs, indicating the presence of unobserved energy.

The proposed model is compatible with quantum theory and relativity. Therefore, we expect to develop a theory that connects micro [16-18] and macro [6,18].

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How do we explore the Universe?

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Abstract: Bulk of the data we receive about our Universe is due to our scientific equipment, which is based on the electro-magnetic interaction. These devices give us a nice picture of the baryonic mater around us, but cannot shed any light on neither dark matter nor dark energy, which occupy a bulk of the Universe's energy balance, but do not participate in this interaction. Recently we opened a new window to the Universe – a field of gravitational observations was born. Although we are just in the very beginning of gravitational observations era and our observatories (Ligo, Virgo and Kagra being main of them so far) have a quite moderate sensitivity, so we can only observe signals from merging of very massive objects, like neutron stars and black holes, this is yet a channel, that, at least in principle, allows a glance to the gravitationally interacting dark matter. Step by step we are improving the sensitivity of the devices in both realms, but we are still so far from unveiling so many mysteries of the Universe. In this paper I give a short overview of electro-magnetic and gravitational observatories humanity has been using so far and say a few words about our nearest future plans in this area.

Keywords: electromagnetic telescopes, gravitational telescopes

1. Introduction

One of humanity's most crucial endeavors has been a search for truth about the Universe we live in. This path started when first man used a stone to crack a nut, or when he looked at the sky on a starry night. Ever since then we use all of our five senses to explore the world through communication with it. We can touch things within the reach of our hands and we can also taste it. We feel smells from dozens of meters and we can hear thunder from the distance of several dozens of kilometers. But these four senses are not quite precise, while our eyesight gives us much more rich and precise information about the world around us. So, it's not surprising, that main trend in the development of scientific devices is connected to the ways for us to see better. We are able to see things as small as a tiny flea and the furthest star our eyes are able to distinguish is 5 kpc away, but human nature restlessly kept asking: how many legs does a flea have, does it have a tail; this star, is it lonely or it has a companion, does it have planets? Humanity will not rest until answers to such questions are found, it's our nature. So, we started inventing devices and techniques to see deeper and further. This let us widen the range of accessible scales allowing us to find clues to some issues, but, at the same time, raising more questions less obvious and more fundamental. It is well known, that with growth of a radius of a sphere its surface area grows quadratically and volume – cubically. So, the more we see and understand about the Universe the more we realize how little do we know about it. Let us see where are we on this exploration journey so far.

2. Vibrations, we are able to detect

Most of the information we receive about the surrounding reality is due to detecting vibrations of different kind. In other words, all of our natural and artificial (devices we use to widen and boost our natural detection abilities) senses detect changes of some physical quantity with time. So, time domain is crucial for modern science. Let us take a closer look at different kinds of vibrations we detect and how do we do it.

2.1. Electromagnetic waves

We may realize it or not, but all of our 5 senses are based on electromagnetism. Touch, smell and taste are due to electromagnetic interaction between different sensitive parts of our body and outside atoms and molecules. We

hear sounds, that are vibrations of gas pressure/density, but these are also solely due to electromagnetic interaction of atoms within gas and between gas and our eardrum. And, of course, light we see with our eyes is a flow of photons – electromagnetic carriers. So all we can detect using our physical body is electromagnetism.

We can touch and taste things within the reach of our hands, we may feel smells from dozens of meters, hear sounds from dozens of kilometers, and the furthest star we can see is roughly 5 kpc away. Among our senses the eyesight is definitely the most precise and informative one, so it has been the main channel for us to explore the Universe. Our eye is an amazing device, which is sensitive even to single photons in certain conditions, but its resolution only allows us to see a 0.05 mm spot and distinguish 2 spots separated by 0.1-0.3 mm with a naked eye. It was quite enough for living during the bulk of human history, but when we realized that there are much smaller objects, our inquisitive scientific mind drew us to creating a lens. It allowed us to see things 20 times smaller, but only piqued our interest and led to the creation of a microscope that got developed and with time added 2 orders of magnitude to the resolution giving us an opportunity to explore the world of bacteria. But what about viruses, molecules, atoms? It is too small to be seen in optical light, because its sizes are smaller than the used light wave length. So, we needed some new principle to detect such tiny objects and it was found in the middle of the past century – we built an electronic microscope, that allows a 20,000,000x magnification due to the use of energetic electrons with de Broglie wavelength as small as fractions of an angstrom. This is as far as we are now in the micro world explorations. But what about space?

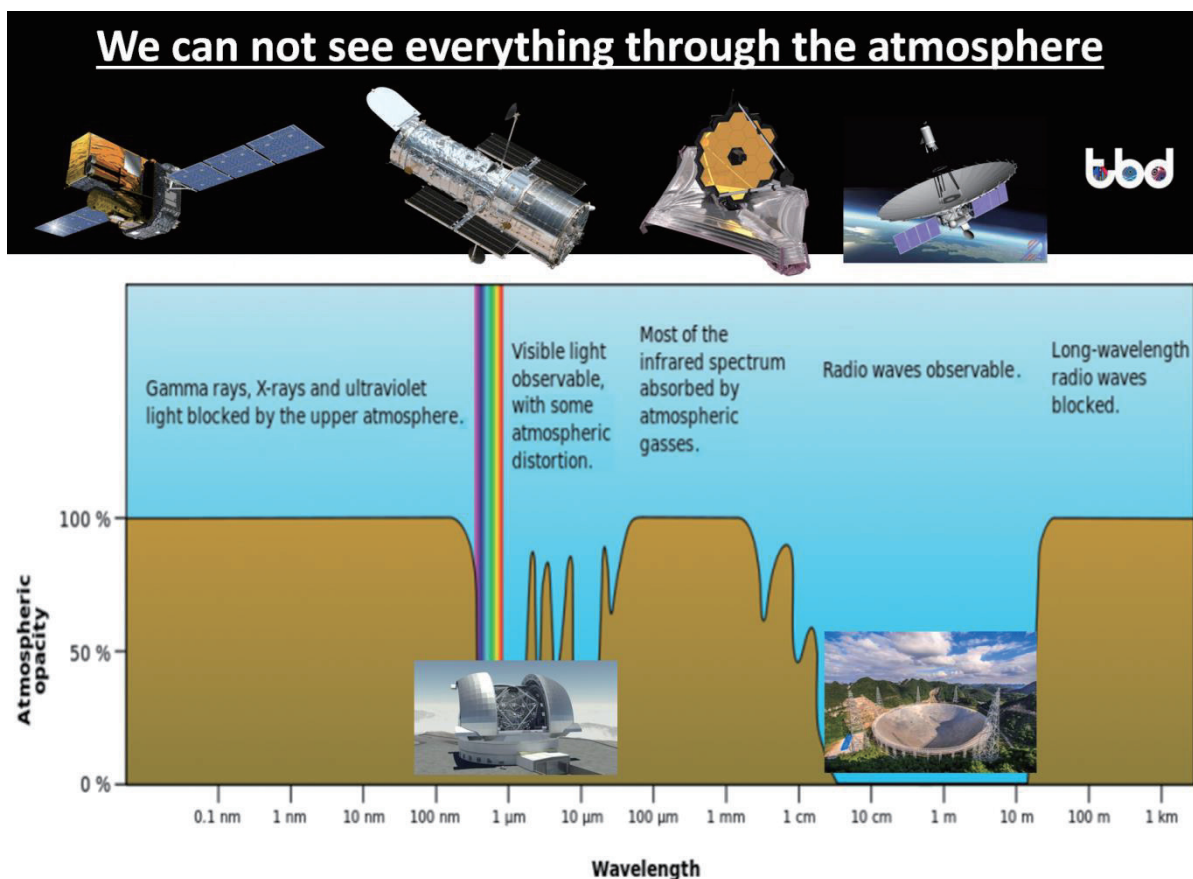


Figure 1. Atmospheric opacity as a function of electromagnetic wave length.

We can see some stars half the way to the center of the Galaxy, but what about fainter stars? What about other galaxies? What about the rest of observable Universe? If we do not take into account rare events of ‘luckily’ collimated radiation we can see almost nothing of it with our naked eye. Actually, we see it, we receive optical photons from quite many objects in the sky, but they are just a few from most of these objects while the background is thousands times greater. To see some more than several thousands of stars we need to have a bigger photon collecting area and gaze longer. Here we face our ‘natural device’ limitations and need to invent some-

thing artificial – a telescope, which differs from our eye mainly in exposure and the area it is able to collect photons from. Though there is yet a third distinguishing feature – it may count the number, energies and detection times of received photons precisely. These 3 features determine the good service telescopes do to us. It allows us to explore stars and other cosmic objects 100 000 000 times fainter than the ones seen with a naked eye.

Of course, observation is far not all that is included in exploration. Theoretical understanding of what we see always went side by side with experiments, sometimes following it, though science knows quite many examples when observations just confirmed theoretical model predictions. Speaking about space research in this manner we would say, that an ancient art of astronomy got accompanied with astrophysics in the beginning of last century. When science addressed the physics of radiative processes in cosmic objects it immediately became clear, that photons of various energies are emitted in most cases and optical light is just a tiny window containing quite a small piece of information about the Universe. It became clear, that we need to develop infrared and radio astronomy as well as ultraviolet, X-ray and gamma ray telescopes and detectors.

As we know now, life quite strongly requires various conditions for it to appear and develop. So, it is quite obvious, that most of the damaging to life hard gamma-ray, X-ray and ultraviolet radiation is blocked by the Earth atmosphere (Fig. 1). Its opacity diminishes in optical part of the spectrum and in short wave radio, but goes up to almost unity for infrared and long radio waves. So, we can build ground radio and optical telescopes, though optical observations are quite sensitive to the atmospheric conditions, so these telescopes are mostly built at high altitudes in driest possible areas. But if we want to explore the Universe in infrared, ultraviolet, X-rays and gamma rays – we need to do it from space. That's why such experiments were not possible (if we do not regard balloon missions) until 1961, when Soviet Union successfully launched a first ever artificial Earth satellite – Sputnik-1, opening a yet very young era of in situ space research. Soon after this first flight we started launching scientific missions into space, that allowed us to tremendously widen our view of the Universe – “An abyss opened full of stars; The stars have no number and the abyss is bottomless” as a great Russian scientist Mikhail Lomonosov said in his famous ode (1743) far ahead of his time.

Though scientific space missions are quite expensive and may often be afforded only by collaborations of countries, there have been several hundreds of them so far. Many are actively working now, providing more and more valuable data in various wave lengths, allowing us to dig into physics and history of the Universe. Multi wave observations allow us to see different processes taking place in cosmic objects, enriching the picture and more effectively constraining our models. We now have over 100 active space missions with scientific equipment onboard with INTEGRAL, XMM-Newton, Chandra, Swift, NUSTAR, Spektr-RG, JWST, Hubble, Gaia et al. among them. The only part of electromagnetic spectrum yet uncovered by space satellites research is a long wave radio range, which is due to the fact that the size of the detector should be close to at least half the registered wave length, but such huge devices are surely yet to come.

No matter how big and powerful will our satellites ever become we can never even come close to the biggest natural telescope humanity has as a gift from the Creator. What do all telescopes basically do? They gather light from huge areas and focus it at one comparatively small detector, usually achieving it through refraction or reflection. But there is yet another way to focus rays we recently started using – we call it gravitational lensing. It is most efficient in the compact areas, containing great amounts of gravitational mass, such as neutron stars and black holes, that concentrate more than a solar mass (sometimes many orders more) in the several kilometers sized sphere. Our Sun's radius is ~700 000 km and yet it may be used as a humanities most powerful telescope – Solar Gravitational Lens (SGL) - someday, and this day is closer than we may expect. All we need to do is to place detector arrays far away from the star: 542 AU distance will provide us with $\sim 10^{-10}$ arc sec resolution and $\sim 10^{11}$ amplification.

2.2. Cosmic rays

Usually to register a photon – find out when and where did it come from and how energetic it was - detector consumes its energy. But to consume cosmic rays - ultra high frequency photons and energetic elementary particles and atom nuclei – it would require a detector too heavy to send it to space. We also know that according to natural order such events are quite rare, so it is almost impossible to study this domain directly, but we can do it using the Earth atmosphere as a part of the detector. When such a photon or particle hits the atmosphere it gives birth to numerous secondary particles of lower energy, conceiving Cherenkov radiation and so called air showers. These cascades of subatomic particles and ionized nuclei may be detected at the ground

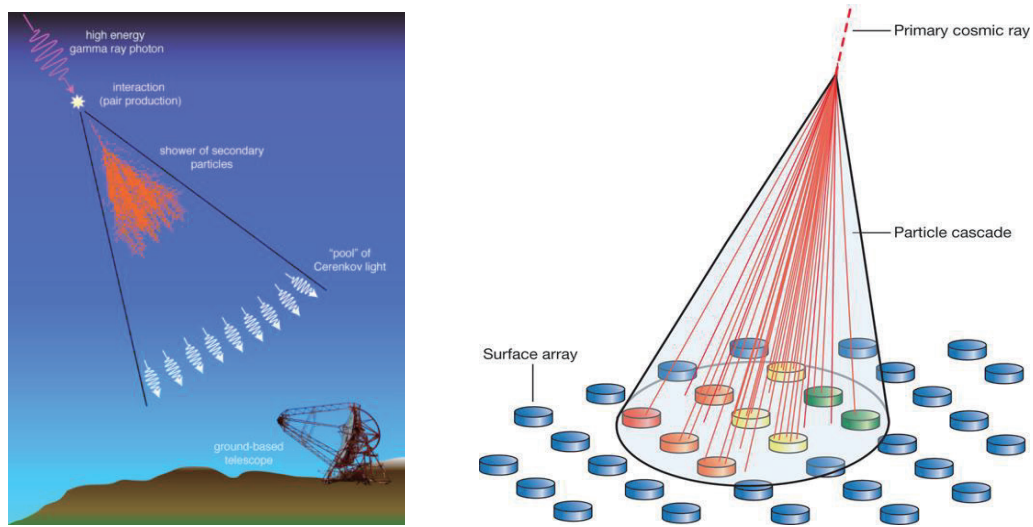


Figure 3. Detection of Cherenkov radiation and air showers from high energy cosmic rays.

with fields of small telescopes occupying square kilometers area. Based on the secondary particles properties we can guess the primary particle energy and a possible range of incidence directions.

2.3. Gravitational waves

It was on August 17th 2017 – only 7 years ago, when we opened a brand new window to the Universe – gravitational wave observations. The existence of such waves has been predicted in theory but we just did not have techniques and expertise to produce devices sensitive enough to detect it. Finally with the latest technology as masterpiece of human achievements we constructed Laser Interferometer Gravitational-Wave Observatory (LIGO) in USA, Virgo in Italy, Kamioka Gravitational Wave Detector (Kagra) in Japan and GEO600 in Germany – main gravitational wave instruments so far. All these are laser interferometers with 2 long arms perpendicular to each other. A coherent light wave is split into two, traveling in each arm and then joining to hit the detector and show an interference pattern. It is easier to detect light, than its absence, so the system is tuned for 2 rays to have a half wavelength difference at the detector and kill each other. When a gravitational wave passes through the observatory it stretches one or both arms so photons of the rays get a difference in travel distance and so the rays get phase shifts and we may detect an appearing interference pattern. After processing detected pictures, usually based on precalculated patterns, we may infer the direction and distance to the source of the wave as well as the type of the event.

The truth is that GW170817 was not the first detection, but it was the first NS-NS merging event confirmed by observations of the electromagnetic counterpart (Fig. 2, left). I happened to be a part of the scientific group, which discovered the second ever observed electromagnetic counterpart of the detected gravitational event – S190425z. Our detection was even more significant than the first one – 5.5 standard deviations over 4.6 (Fig. 2, right).

Modern theory states, that among massive compact objects interactions only baryonic matter containing NS-NS or NS-BH merging binary systems will produce electromagnetic radiation. But there are some exotic models, that predict such a radiation even from BH-BH mergings in some specific cases. In particular, if BH masses in such a system differ a lot (like a mass-constrained primordial black hole and a supermassive black hole) and the system is inclined in a 'nice' way, so we see a straight line radial fall of smaller BH to the bigger one, a Lorentz-boosted Hawking radiation may result in a highly collimated thermal beam, that, in principle, may be observable (O. Barco et al., 2021). One of the projects I am currently working on is dedicated to the search for such radiation using the INTEGRAL orbital observatory capabilities.

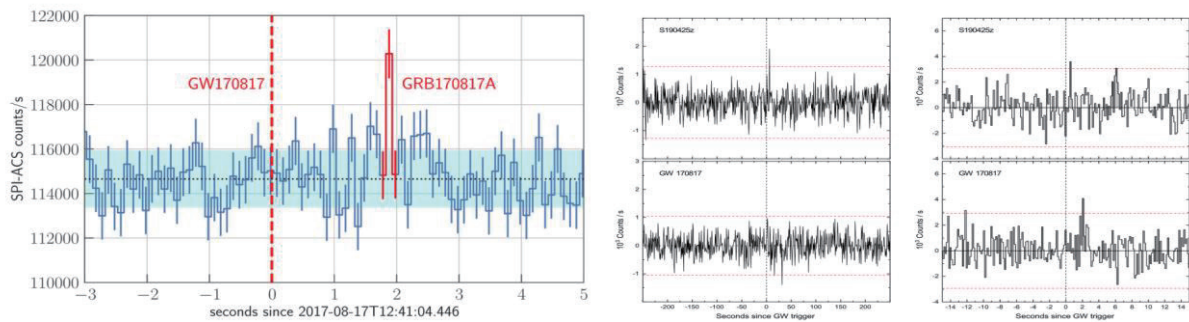


Figure 2. Left: INTEGRAL detection of the first prompt gamma-ray signal coincident with the gravitational-wave event GW170817 (Savchenko et al., 2017). Right: Observation of the second LIGO/Virgo event connected with a binary neutron star merger S190425z in the gamma-ray energy range (Pozanenko et al., 2020).

The laser interferometer technique is most sensitive, but there are other and most of them are constantly being developed. LIGO, Virgo and Kagra, for example, are working in runs (now O4 run is in process) and their equipment is updated between runs using latest achievements of science and technology to gain a better sensitivity in every new run. So we may hope for detection of gravitational signals from further and less massive objects. We live in the very beginning of gravitational observations era and this field has a bright future, that will become present within our lifetime.

2.4. What else?

Last century was pretty rich on discoveries. In particular we realised that something like dark matter and dark energy should exist. None of these seem to take part in electromagnetic interaction, so we have a standing question of how can we detect it. We can see the effect of dark matter on gas and stars in a galaxy and use dark energy to explain accelerated expansion of the Universe, but are we able to find a way to detect it directly? As it was mentioned above, all we detect is vibrations, so, may be dark matter and dark energy are also vibrations of some physical quantities? Then what quantities are these? And how can we detect this nonbaryonic matter substances? These questions remain and become more and more important issues as we dig deeper into the Universe.

And there is definitely a greater challenge ahead of us. Even now almost 90% of human beings are believers. Based on our experience most of us believe in the existence of some other reality, hosting our souls. We can call it spiritual world. If it exists it will become of great interest to scientists quite soon. It seems like we are coming closer and closer to the roots of physical world mysteries due to high development of theory and devices, and it will push us towards the research concerning the other reality. It is of course an open question whether it exists or no, and if it does, is there a possibility of detecting it using physical equipment? In this case we have at least one living proof of possible success and it is our bodies, which are quite physical, and yet able to respond to signals from the spiritual world. So some part of it, like brain, or it is as a whole has this ability. At the same time, animals are thought not to have a soul, but seem to be somewhat sensitive to spiritual reality, so simple body comparison won't be sufficient to find out the principle of interaction. As more than a half of humanity (Abrahamic religions) believes, spiritual world, the world of angels was created prior to physical realm. One of the most crucial questions science will have to first deal with is whether spiritual world is primary and physical world was created based on the spiritual realm, so physical energy is nothing but a derivative of spiritual one, or are these two created equally using some third primary energy? We are yet of course far away from such issues but correct understanding of this structure will help in establishing a correct model of the reality which is as always crucial to the success of practical experiments.

3. Conclusions

Reviewing our current scientific achievements we have to admit that we mastered a certain level of detecting and researching of electromagnetic vibrations that revealed to us a vast variety of baryonic matter. But at the same time it widened our horizon and such entities as dark matter, dark energy and even spiritual reality came into our scope. What are they? Are they also vibrations of some field? If spiritual realm is not material, the concept of time is not applicable to it, so what vibrations may we be talking about? Or, may be, there is some other entity

occupying the role of time in the spiritual world? Questions we raise here are much more numerous than answers we think we have.

We are currently in the very beginning of the path to answer these questions. But we are far enough to actually raise them! As history teaches us the time between raising questions and answering them gradually diminishes. For example space research and consequent spheres of gravitational observations, dark matter and dark energy are just 60 years old, and yet how far did we get in these areas! So we may hope that humanity will see the light in this direction within this century. Of course it will require a correct direction of the science development to be chosen.

Indeed, I would say, that of all the scientific endeavors humanity has taken so far the one concerning uncovering the mysteries of spiritual reality is most crucial, because it allows us to realize what role our current earthly life plays in our overall existence and may help us be wiser in preparation to the post-physical life journey, if there is one.

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Session 3

**Bio Science
for Co-Prosperity**

The Antarctic Frontier: Source of Novel Bioactive Compounds

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Abstract: The extreme environment of Antarctica fosters the production of unique secondary metabolites by its native lichens, mosses, and bacteria. These natural products present valuable opportunities for drug discovery due to their distinctive bioactivities and chemical diversity. In this study, the potential of Antarctic-derived metabolites was examined and emphasized the role of advanced analytical and computational techniques in investigating these compounds. Our studies have demonstrated that extracts from Antarctic mosses, lichens, and bacteria exhibit significant bioactivities, including anticancer, antituberculosis, anti-obesity, and anti-diabetic effects. By integrating metabolomics within silico analyses, we were able to swiftly and precisely identify bioactive compounds. The use of molecular networking allowed us to map and categorize related metabolites, while molecular docking and ADME (absorption, distribution, metabolism, and excretion) evaluations provided insights into their pharmacokinetic properties and therapeutic potential. This robust methodological approach has led to the identification of several promising bioactive compounds, highlighting the potential of these Antarctic organisms in drug development. Looking ahead, we advocate for the inclusion of genetic analysis and synthetic biology techniques to further investigate and harness these natural products. Genetic studies can elucidate biosynthetic pathways, and synthetic biology can facilitate the optimization and scalable production of these bioactive compounds. In summary, the combination of metabolomics, in silico analysis, genetic research, and synthetic biology offers a powerful strategy for discovering novel pharmacologically active compounds from Antarctic natural products. This study seeks to spotlight the untapped potential of these resources and promote their integration into the drug discovery pipeline.

Keywords: Antarctic organisms, non-targeted metabolomics, pharmacological properties, synthetic biology

1. Introduction

Antarctica, the most extreme and remote continent on Earth, presents a unique environment where native organisms have evolved distinct survival strategies. This harsh habitat has led to the production of unique secondary metabolites by lichens, mosses, and bacteria, which are of significant interest for drug discovery [1,2]. These natural products hold distinctive bioactivities and chemical diversity, making them valuable for the development of new pharmaceuticals. Recent advancements in analytical and computational methods have significantly enhanced the exploration of these Antarctic-derived metabolites, allowing for more precise and efficient investigation of their properties [3].

The focus of our study is to examine the potential of secondary metabolites from Antarctic organisms, particularly several species of mosses/lichens, and three bacterial genera. Our aim is to identify and characterize bioactive compounds with therapeutic potential, utilizing a robust methodological approach that integrates metabolomics, in silico analyses, genetic research, and synthetic biology. Through this multidisciplinary strategy, we seek to highlight the untapped potential of Antarctic natural products and promote their integration into the drug discovery pipeline.

This paper outlines the methods and results of our comprehensive study, demonstrating the significant bioactivities exhibited by extracts from Antarctic mosses, lichens, and bacteria, including anticancer, antituberculosis, anti-obesity, and anti-diabetic effects. We employed advanced analytical techniques such as high-resolution mass spectrometry (HRMS) and nuclear magnetic resonance (NMR) for compound structural analysis, and preparative high-performance liquid chromatography (Prep HPLC) for compound purification. Feature-based molecular networking using MZmine3 and the Global Natural Products Social Molecular Networking (GNPS) platform facilitated the identification and categorization of related metabolites [4-6]. Furthermore, molecular docking using AutoDock Vina [7] and ADME (absorption, distribution, metabolism, and excretion) analysis via SwissADME [8] provided insights into the pharmacokinetic properties and therapeutic potential of the identified compounds.

The biosynthetic gene clusters (BGCs) were analyzed using antiSMASH [9] to understand the biosynthetic pathways involved.

In summary, this paper seeks to provide a detailed account of our methodologies, findings, and the implications of our research, promoting the exploration and utilization of Antarctic natural products in the development of novel pharmaceuticals.

2. Materials and Methods

2.1. Sample Collection and Preparation

Samples of several species of Antarctic mosses/lichens, and three bacterial genera obtained from the Polar Natural Product Chemistry Laboratory of the Korea Polar Research Institute. The samples were carefully transported to the laboratory and stored at appropriate conditions to preserve their bioactive compounds. The mosses and lichens were air-dried and ground into a fine powder, while bacterial cultures were grown on suitable media and harvested.

2.2. Sample processing and extraction

The metabolites were extracted using a solvent extraction method. For mosses and lichens, 10 grams of dried powder were soaked in 100 ml of methanol and left to macerate for 72 hours. The extracts were filtered and concentrated under reduced pressure. Bacterial metabolites were extracted from the culture medium using ethyl acetate after removal of bacterial cells by centrifugation. The concentrated extracts were stored at -20°C until further analysis.

2.3. Metabolic profiling

Metabolomics was conducted using feature-based molecular networking (FBMN) facilitated by MZmine3 and GNPS. The extracts were analyzed using HRMS to detect and quantify the metabolites. The mass spectrometry data were processed using MZmine3 to generate a feature table, which was then uploaded to the GNPS platform for molecular networking. This approach allowed for the visualization and categorization of related metabolites based on their mass spectrometric features. The resulted files were downloaded as a graphML network file and visualized in Cytoscape [10].

2.4. Compound Purification and Structural Analysis

Bioactive compounds were purified using Prep HPLC. The purified compounds were then subjected to structural analysis using NMR and HRMS. These techniques provided detailed information on the molecular structures of the compounds.

2.5. In silico analysis

Molecular docking studies were performed using AutoDock Vina to predict the binding affinity of the identified compounds to specific protein targets. The protein targets were selected based on their relevance to the observed bioactivities (anticancer, antituberculosis, anti-obesity, and anti-diabetic effects). The pharmacokinetic properties of the compounds were evaluated using SwissADME. This in silico tool provided insights into the drug-likeness and potential therapeutic efficacy of the compounds. The BGCs responsible for the production of the bioactive compounds were analyzed using antiSMASH. This tool allowed for the identification and characterization of the genetic pathways involved in the biosynthesis of the secondary metabolites.

3. Results

3.1. Bioactive Metabolites from Antarctic Mosses, Lichens, and Bacteria

The extracts from the three species of mosses, lichens, and bacterial genera exhibited significant bioactivities in various assays. Notably, several extracts demonstrated potent anticancer, antituberculosis, anti-obesity, and anti-diabetic effects.

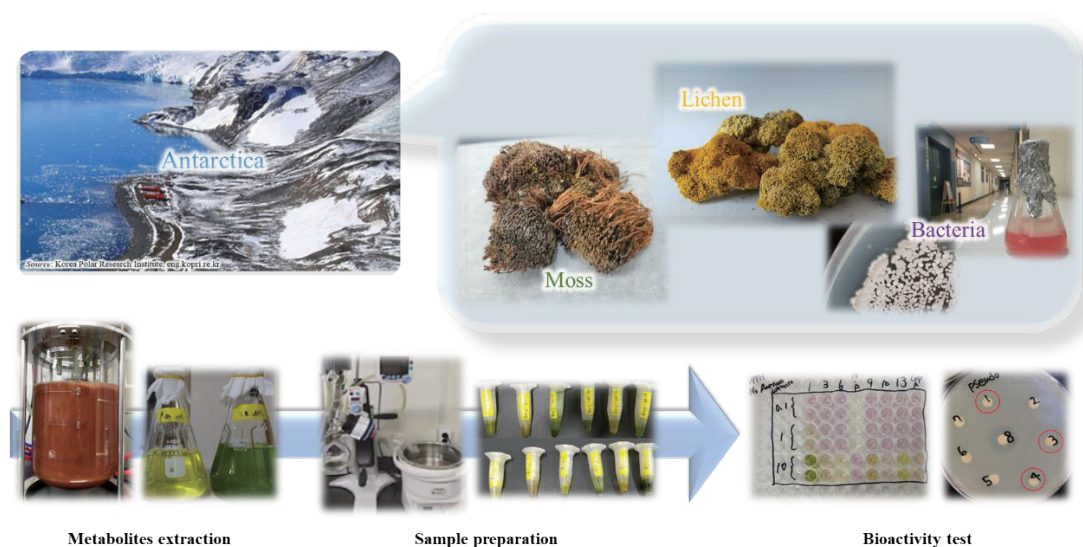


Figure 1. Our research workflow for the screening sample.

3.2. Untargeted metabolic profiling on Moss/Lichen metabolites

FBMN analysis using GNPS revealed distinct clusters of metabolites, suggesting compounds present within the extract. A list of compounds detected within methanol extracts of Antarctic mosses as one of several samples is shown in Table 1.

Table 1. Library hits found in the spectra of the methanolic extract of Antarctic moss through the FBMN analysis. Cosine : normalized dot-product, a mathematical measure of spectral similarity between two fragmentation spectra. MZErrorPPM: ppm error with the spectral library match, LibMZ: m/z value of the spectral library match

No.	Compound Name	Library Class	Cosine	MZErrorPPM	LibMZ
1	hyocholic acid	Gold	0.89	1	158.15
2	Spectral Match to D-Fructose from NIST14	Bronze	0.98	2	180.09
3	NCGC00385962-01_C16H24O3_	Gold	0.92	12	247.17
4	Spectral Match to Tributyl phosphate from NIST14	Bronze	0.86	1	267.17
5	Massbank:LU030803 Lauryldiethanolamine[2-(dodecyl(2-hydroxyethyl)amino)ethanol	Bronze	0.9	1	274.27
6	Spectral Match to 9-Octadecenamide, (Z)- from NIST14	Bronze	0.84	1	282.28
7	Sucrose	Bronze	0.95	3	325.11
8	Spectral Match to 13-Docosenamide, (Z)- from NIST14	Bronze	0.9	0	338.34
9	SUCROSE	Bronze	0.93	0	343.12
10	CELLOBIOSE	Bronze	0.85	1	360.15
11	Spectral Match to Tris(2-butoxyethyl) phosphate from NIST14	Bronze	0.92	0	399.25
12	Spectral Match to Lyso-PC(16:0) from NIST14	Bronze	0.95	0	496.34
13	PC(18:3/0:0); [M+H] ⁺ C26H49N1O7P1	Gold	0.88	2	518.33
14	Melezitose	Bronze	0.96	1	522.2
15	Contaminants septum vial Thermo C4000-53 and C4000-54 serie	Bronze	0.91	1	536.16
16	Pheophorbide A	Bronze	0.81	9	593.27
17	ACARBOSE	Bronze	0.89	13	684.21
18	Stachyose	Bronze	0.79	0	689.21
19	Pheophytin a	Bronze	0.89	0	871.57

3.3. Molecular docking and ADME analysis

Molecular docking studies were performed using AutoDock Vina to predict the binding affinity of the identified compounds to specific protein targets. The protein targets were selected based on their relevance to the observed bioactivities (anticancer, antituberculosis, anti-obesity, and anti-diabetic effects).

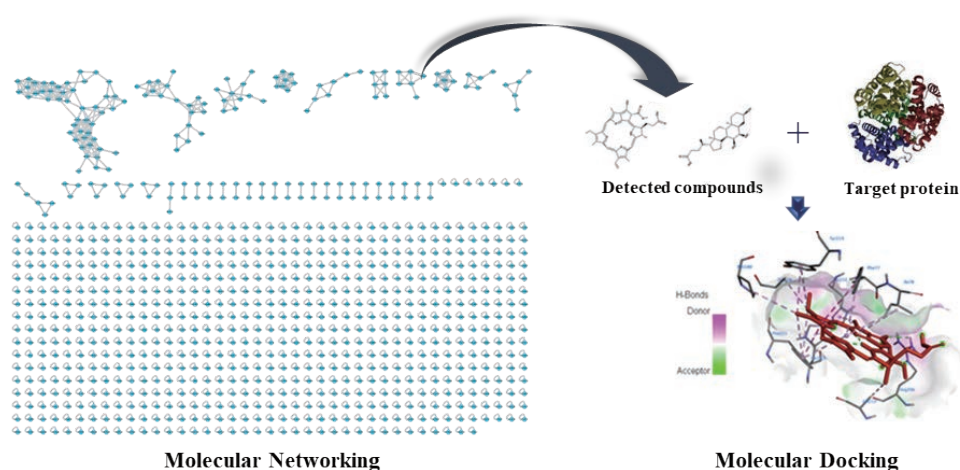


Figure 2. Graphical summary of in silico analysis. Compounds present in the extract are detected by the molecular network and their binding affinity to the target protein is evaluated.

The pharmacokinetic properties of the compounds, including absorption, distribution, metabolism, and excretion (ADME), were evaluated using SwissADME predicted favorable pharmacokinetic properties for several compounds, including good oral bioavailability and low toxicity.

3.4. Biosynthetic Gene Cluster (BGCs) Analysis

The BGCs using antiSMASH revealed the genetic basis for the production of the secondary metabolites in bacterial genome. For example, the BGC responsible for the polyketide in *Streptomyces* was characterized, providing insights into the enzymatic steps involved in its biosynthesis. This information is crucial for potential synthetic biology applications aimed at optimizing and scaling up the production of these bioactive compounds.

4. Discussion

Antarctic mosses, lichens, and bacteria produce unique secondary metabolites with significant therapeutic potential. Our study demonstrates that integrating metabolomics, in silico analyses, and genetic research is effective for identifying and characterizing these bioactive compounds. Advanced techniques like HRMS, NMR, and Prep HPLC allowed precise identification and purification, while molecular networking highlighted chemical diversity. Molecular docking and ADME analyses provided insights into pharmacokinetics and therapeutic efficacy. To fully harness the potential of Antarctic natural products, further studies should incorporate genetic analysis and synthetic biology techniques. Genetic studies can elucidate the biosynthetic pathways of bioactive compounds, enabling the manipulation of these pathways for optimized production. Synthetic biology can facilitate the scalable production of these compounds, making them more accessible for pharmaceutical development. While the extreme environment of Antarctica poses challenges for sample collection and preservation, it also offers unique opportunities for discovering novel bioactive compounds. The integration of multidisciplinary approaches is essential for overcoming these challenges and maximizing the potential of Antarctic natural products in drug discovery.

5. Conclusions

This study highlights the immense potential of Antarctic lichens, mosses, and bacteria as sources of unique secondary metabolites with bioactive anticancer, antituberculosis, anti-obesity, and anti-diabetes properties. By utilizing advanced analytical and computational techniques such as metabolomics, molecular networking, molecular docking, and ADME evaluation, several promising bioactive compounds were efficiently identified and characterized. In addition, genetic studies can elucidate biosynthetic pathways, and synthetic biology can optimize and scale up the production of these bioactive molecules. Such a comprehensive strategy will not only accelerate the drug discovery process, but also ensure a sustainable supply of novel pharmacologically active compounds. In summary, Antarctic natural products represent an untapped reservoir of novel drug candidates. Our study

also advocates that the integration of metabolomics, in silico analysis, genetic research, and synthetic biology has great potential in advancing pharmacology and solving unmet medical needs.

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A Comprehensive Metabolomics and *In Silico* Study: Antarctic Moss as a Source of Bioactive Compounds

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Abstract: Metabolic syndrome (MetS) is a global public health issue that significantly increases morbidity and mortality while decreasing the quality of life. Characterized by symptoms such as insulin resistance and dyslipidemia, it necessitates therapeutic strategies including the inhibition of enzymes involved in nutrient absorption and digestion. Natural products, especially those sourced from extreme environments like Antarctica, offer unique chemical structures suitable for drug discovery. In this study, metabolites were extracted and profiled from a rare Antarctic moss, named An-MS1. The spectral data obtained from LC-MS/MS analysis of the methanol extract were processed to construct a molecular network, revealing the presence of 17 compounds. The pharmacological potential of the identified compounds was investigated through comprehensive *in silico* analysis. Molecular docking analysis was initially conducted to assess their interactions with target enzymes involved in MetS, specifically amylase, glucosidase, and lipase. The docking studies indicated significant inhibitory activity of several compounds against these enzymes. Furthermore, molecular dynamics simulations and SwissADME pharmacokinetic analyses were performed to evaluate the stability and pharmacological properties of the identified compounds. The results demonstrated that the identified compounds possessed favorable pharmacokinetic profiles and strong potential as novel enzyme inhibitors. This study reports the successful metabolite profiling of an Antarctic-derived moss and highlights its potential as a source of bioactive compounds for drug discovery. The findings suggest that a combined approach of metabolomics and *in silico* analysis can effectively accelerate the identification of new drug candidates from rare natural samples, which may have been previously overlooked.

Keywords: antarctic moss, metabolic syndrome, LC-MS/MS analysis, molecular docking, molecular dynamics simulation, pharmacokinetic analysis

1. Introduction

Natural products have historically been a rich source of pharmacologically active compounds. Extreme environments such as Antarctica have unique flora that produce metabolites with unique chemical structures that may provide novel bioactive compounds. For example, Antarctic mosses are adapted to harsh conditions such as low temperatures, aridity, intense UV radiation, and nutrient deficiencies, and are known to produce unique secondary metabolites with important pharmacological properties [1].

Metabolic syndrome (MetS) is a multifaceted public health challenge and a major contributor to rising morbidity and mortality worldwide. MetS is characterized by a series of conditions including insulin resistance, dyslipidemia, hypertension, and central obesity, which increase the risk of developing obesity and type 2 diabetes [2]. Current treatment strategies focus primarily on lifestyle modification and pharmacological interventions that target underlying pathophysiological mechanisms.

Enzyme inhibitors, such as those that inhibit amylase, glucosidase, and lipase, are essential for managing MetS by reducing nutrient absorption and digestion [3]. However, all existing enzyme inhibitors have been reported to have side effects, and new compounds with improved efficacy and safety are constantly sought.

In this study, we aimed to identify novel enzyme inhibitors for the treatment of MetS by combining metabolic profiling of a rare Antarctic moss, named An-MS1, with comprehensive *in silico* analysis. This integrated approach aims to accelerate the identification of promising drug candidates from rare natural resources.

2. Method

2.1. Sample Collection and Extraction

An-MS1 was obtained from the Polar Natural Products Chemistry Laboratory of the Korean Polar Research Institute.

Samples were dried and ground before use. 1 g of the powdered An-MS1 was placed in a flask with 100 mL of MeOH and stirred in the dark at room temperature for 3 hours. It was then extracted.

2.2. Metabolite Profiling

Metabolite profiling of An-MS1 was performed using non-targeted LC-MS/MS analysis. The MS/MS data obtained were processed on the GNPS platform to construct a molecular network to facilitate the identification of metabolites based on fragmentation patterns.

2.3. In Silico Pharmacological Analysis

2.3.1. Molecular Docking

Molecular docking was performed using AutoDock Vina [4] to evaluate the interaction of the identified metabolites with the major enzymes involved in MetS (amylase, glucosidase, and lipase). Crystal structures (2QMJ, 1SMD, 1LPB) of these enzymes were obtained from the Protein Data Bank (PDB). Docking protocols prepared protein and ligand structures, defined docking grids, and performed docking simulations. Metabolite binding affinities and interaction modes were analyzed to identify candidate enzyme inhibitors.

2.3.2. Molecular Dynamics Simulation

MD simulations were performed using CABS-flex 2.0 (<http://biocomp.chem.uw.edu.pl/CABSflex2>) (accessed on 2024 May 20) [5] to evaluate the stability of the protein-ligand complexes identified in the docking study. The simulations provided insight into the dynamic behavior of the complex and its stability over time. Root mean square fluctuations (RMSF) were calculated to assess the structural stability and flexibility of the complex.

2.3.3. Swiss ADME analysis

Pharmacokinetic properties of identified metabolites were evaluated using the SwissADME tool [6]. Parameters such as absorption, distribution, metabolism, and excretion (ADME) were analyzed to predict the drug similarity and potential bioavailability of the compounds.

3. Results and Discussion

3.1. Metabolite Identification

LC-MS/MS analysis of An-MS1 methanol extracts revealed a complex mixture of metabolites. GNPS was used to construct a molecular network and 17 compounds were identified. These compounds were annotated based on MS/MS fragmentation patterns and comparison to known metabolite databases. Table 1 shows the results.

Table 1. LC-MS/MS chemical profiling of An-Ms1

Compounds	Library Class	MZErrorPPM	Instrument	PI	Ion Source
Compound 1	Gold	1	Orbitrap	Dorreestein	ESI
Compound 2	Bronze	9	qTof	Pieter Dorreestein	LC-ESI
Compound 3	Gold	11	Maxis II HD	Jadhav/Dorreestein	LC-ESI
DGTS 16:0	Bronze	2	Orbitrap	Quinn	LC-ESI
1-Linoleoyl-sn-glycero-3-phosphocholine	Gold	2	HCD; Velos	Thomas Metz	LC-ESI
Sucrose	Bronze	0	Orbitrap	MoNA	ESI
Tris(2-butoxyethyl) phosphate	Bronze	2	Hybrid FT	Massbank	ESI
SCHEMBL26641914	Gold	2	HCD; Velos	Thomas Metz	LC-ESI
Lysophosphatidylcholine(16:0)	Bronze	0	qTof	Julia Gauglitz	ESI
Bis(2-ethylhexyl) phthalate	Bronze	1	QQQ	Gabriel Haddad	ESI
LysoPC(18:3(6Z,9Z,12Z))	Bronze	5	qTof	Massbank	ESI
Melezitose	Bronze	1	ESI-QFT	MoNA	N/A
1-(9Z,12Z-octadecadienoyl)-sn-glycero-3-phosphocholine	Bronze	3	qTof	Massbank	ESI
Phthalic anhydride	Bronze	1	qTof	Maria Maansson	ESI
Lactulose	Bronze	1	qTof	MoNA	ESI
Dianthoside	Gold	2	Maxis II HD	Jadhav/Dorreestein	LC-ESI
Didodecyl 3,3'-sulphinylbispropionate	Bronze	1	QqQ	Pieter Dorreestein	ESI

3.2. Molecular Docking

Molecular docking studies showed that Compound 1, 2 and 3 showed significant binding affinity to the target enzymes amylase, glucosidase, and lipase (Figure 1).

Docking poses revealed that hydrogen bonds and hydrophobic interactions interact with the active site of the enzyme, suggesting its potential as an effective enzyme inhibitor.

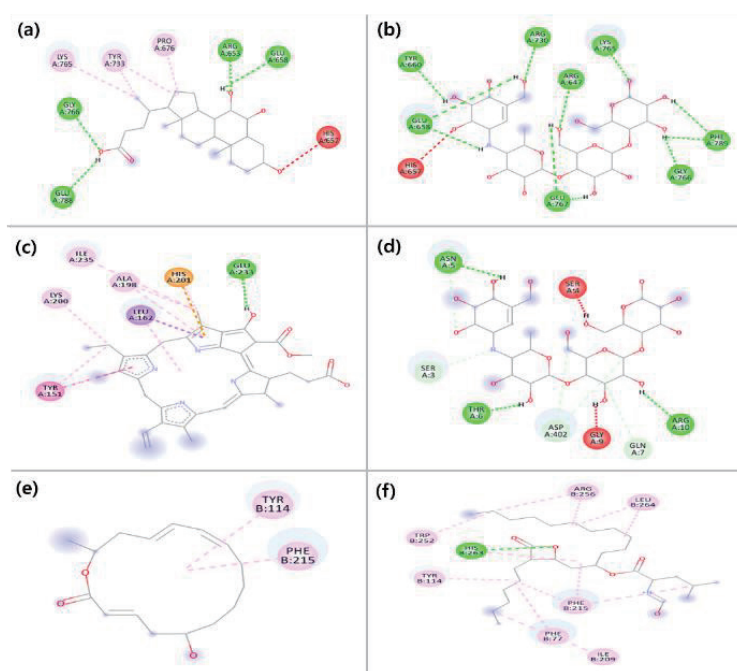


Figure 1. 2D interaction visualization by bio discovery studio: (a) Compound 1- α -glucosidase; (b) Acarbose- α -glucosidase; (c) Compound 2- α -amylase; (d) Acarbose- α -amylase; (e) Compound 3-lipase; (f) Orlistat-lipase.

3.3. Molecular Dynamics Simulation

MD simulations provided further insight into the stability of the protein-ligand complex. The RMSF values indicated that the complex was stable throughout the simulation period, with minimal fluctuations in the binding region. This stability suggests that the identified compounds can form stable interactions with the target enzyme, strengthening their potential as enzyme inhibitors. Results are shown in Figure 2.

Table 2. Swiss ADME parameters of the candidate compounds, Acarbose and Orlistat

Compound name	TPSA (\AA^2)	CLogP	PAINS alert	Lipinski violation
Compound 1	97.99	2.91	0	0
Compound 2	132.94	3.77	0	1
Compound 3	46.53	2.93	0	0
Acarbose	321.17	-6.06	0	3
Orlistat	81.7	7.05	0	1

3.4. Pharmacokinetic Analysis

SwissADME analysis revealed that the identified compounds have good pharmacokinetic profiles. Most of the compounds met Lipinski's 5 laws, indicating good oral bioavailability. In addition, these compounds had low predicted toxicity and good ADME properties, making them promising candidates for further drug development (Table 2).

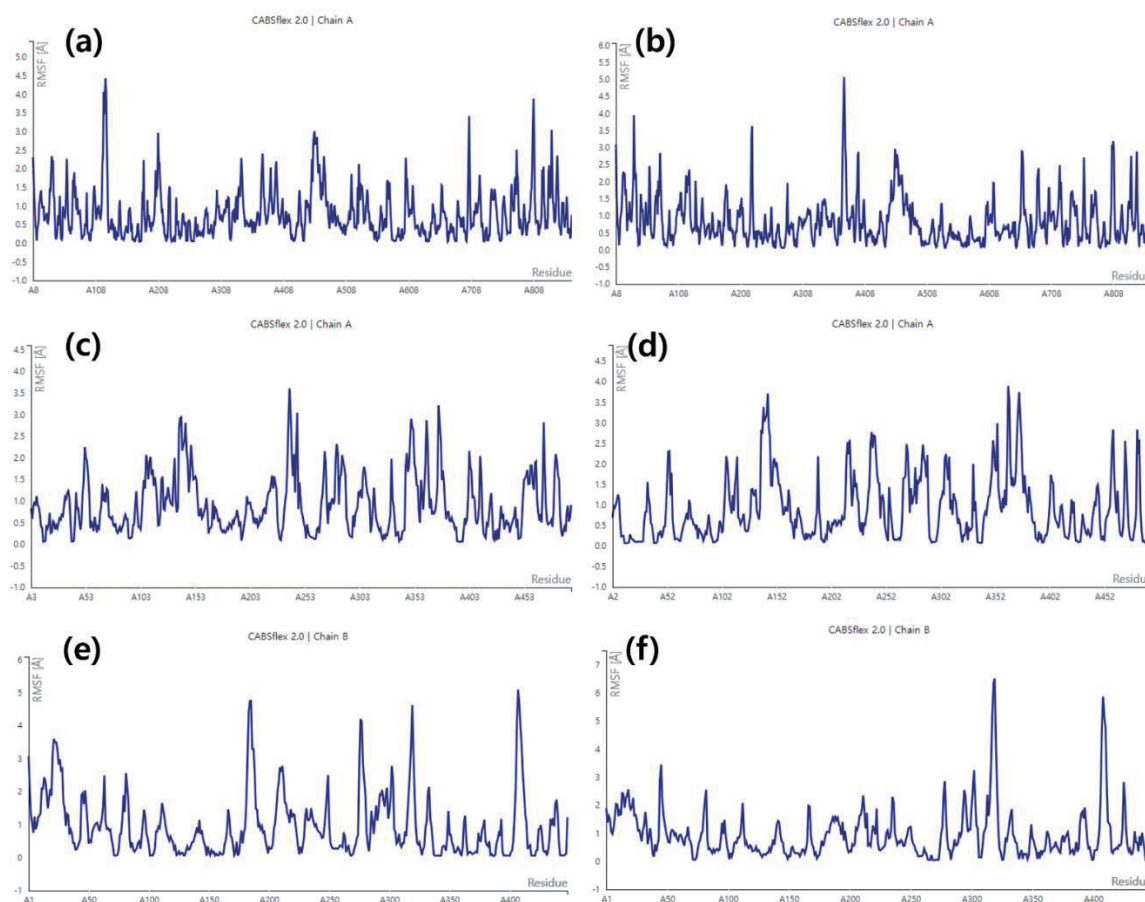


Figure 2. RMSF of each target protein and complexes: (a) α -glucosidase; (b) Compound 1- α -glucosidase complex; (c) α -amylase; (d) Compound 2- α -amylase complex; (e) Lipase; (f) Compound 3-lipase complex.

4. Summary and Discussion

Comprehensive analysis of Antarctic moss An-MS1 highlights its potential as a source of novel bioactive compounds for MetS therapy. The unique environmental conditions of Antarctica may contribute to the production of distinct secondary metabolites with important pharmacological properties. The identification of 17 compounds by LC-MS/MS and GNPS highlights the chemical diversity present in An-MS1. *In silico* pharmacological analysis, including molecular docking and MD simulations, provides strong evidence that these compounds have inhibitory capacity against key enzymes involved in MetS. The stability and favorable pharmacokinetic profiles of the identified compounds further support their potential as novel therapeutic agents. Evaluation of the drugability of the compounds using SwissADME confirms that the identified candidate compounds have properties suitable for drug development. This study demonstrates that metabolomics combined with *in silico* analysis can accelerate the discovery of new drug candidate compounds from rare natural resources. This finding suggests that An-MS1 and similar Antarctic mosses could be valuable resources in the search for novel treatments for MetS and other related diseases. Future studies should focus on the isolation and characterization of these compounds, followed by *in vitro* and *in vivo* evaluation to confirm their therapeutic potential.

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Conflicts of Interest: The authors declare no conflict of interest.

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Structural analysis of Chalcone synthase-like gene from *Senna occidentalis*

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Abstract: *Senna occidentalis* is one of the plants well known for the biosynthesis of anthraquinone, has a variety of pharmacological properties. *Senna occidentalis* biosynthesizes not only flavonoids such as quercetin, kaempferol, and apigenin, but also various types of anthraquinone such as emodin, aloe-emodin, physcion, chrysophanol, and rhein. The biosynthetic pathway of anthraquinone has been identified in bacteria and fungi, but the overall biosynthetic pathway in plants is still unknown. To date, plant anthraquinone biosynthetic pathway is expected to be the chorismite/O-succinylbenzoic acid pathway and the polyketide pathway. Through analysis of the transcriptome, genome, and metabolome of the *Senna* genus, we predicted that the anthraquinone biosynthesis of *Senna occidentalis* is associated the polyketide pathway, and identified and characterized the chalcone synthase-like gene, the most important core enzyme in the biosynthetic pathway. SocCHS-L2 with a length of 395 aa was characterized to produce atrochryson carboxylic acid and endocrocin anthrone using 8 malonyl-CoA through LC-MS/MS. And through X-ray crystallography, the structure of SocCHS-L2 was confirmed. Compared to *Medicago sativa* CHS, a well-known plant type III PKS structure, the catalytic residues (Cys-His-Asn) of Soc-CHS-L2 were conserved, but Phe265 of initiation pocket was replaced with Tyr264 in SocCHS-L2. It was rotated into a sieve parallel to the internal tunnel through a T-shaped π -stacking interaction with Phe214, unlike other plant type III PKSs, is a factor that causes the formation of a long, parallel tunnel-shaped condensation pocket in the direction of the dimer interface. *Aloe arborescens* OKS (ArOKS), which forms the same octaketide intermediate, has a larger condensation pocket than SocCHS-L2, but due to a series of restriction in the internal cyclization of the intermediate due to the bent condensation pocket, it produces SEK4 or SEK4b. The structure of SocCHS-L2 provides insight into the biosynthesis of anthraquinone during a series of condensation and cyclization within a type III PKSs.

Keywords: Anthraquinone, Type III polyketide synthase, Octaketide synthase

1. Introduction

Anthraquinones are a type of polycyclic compound that feature a quinonoid structure and are found in a diverse array of organisms, including bacteria, fungi, algae, insects, and plants [1]. Chemically, anthraquinone are derived from a 9,10-antracene structure that consists of three benzene rings labeled as A, B, and C [Duval et al., 2016; Lu et al., 2013]. The chemical and structural diversity of anthraquinones is determined by the substitution of the hydrogen atoms in their core structure with various functional groups such as -OH, -CH₃, -OCH₃, -CH₂OH, -CHO, and -COOH. This substitution pattern forms one of the most significant groups of anthraquinone compounds [2]. For example, numerous derivatives are formed depending on the presence of hydroxyl, methoxy, methyl radicals, hydroxymethyl, and glycoside groups on the A and C rings.

Anthraquinones are abundant in plants from families such as Polygonaceae, Rubiaceae, Rhamnaceae, and Leguminosae. But, in plant anthraquinone biosynthetic process, there is no definitive clue as to how to biosynthesis the anthraquinone. Previous research suggests that anthraquinones can be synthesized through these pathways: the o-succinylbenzoate pathway and polyketide pathway. However, studies identifying the key enzyme genes involved are still insufficient, and there is a lack of direct and compelling evidence to fully elucidate these biosynthetic mechanisms. This gap highlights the need for further investigative efforts to understand the genetic and enzymatic underpinnings of anthraquinone biosynthesis, which could significantly enhance our knowledge of plant secondary metabolism and its applications in various industries.

In previous research [3], we confirmed through *in-vitro* reactions that a chalcone synthase-like enzyme, a class of Type III Polyketide Synthase (PKS), produces atrochryson carboxylic acid and endocrocin anthrone, which

are precursors of emodin. In this study, we aim to identify chalcone synthase-like enzymes involved in the anthraquinone biosynthetic pathway in *Senna occidentalis*, a plant of the same genus as *Senna tora*. By analyzing the activity and structure of this enzyme, we seek to provide a deep understanding and insight into the biosynthesis of anthraquinone compounds by plant.

2. Materials and Methods

2.1. Bacterial over-expression and protein purification

For over-expression, the recombinant strains of *Senna* genus CHS-like genes were cultured in 3 ml of LB containing 100 µg/ml of ampicillin at 37 °C for 6 hours, and well-grown cells were transferred to 100 ml in 250 ml flask. When the optical density of the cultures at 600 nm reached 0.3-0.7, 0.5 mM IPTG was added into the cultures to induce the recombinant protein expression. After an incubation at 20 °C for 36-48 hours, the cells were harvested by centrifugation at 3,500 rpm for 15 min at 4 °C. Harvested cells were washed twice using 50 mM potassium phosphate buffer (pH 7.4) and resuspended with 10 ml of 50 mM potassium phosphate buffer (pH 7.4). The samples were disrupted by sonication. The homogenate was centrifuged at 13,500 rpm for 15 min at 4 °C to be isolated from insoluble fraction. The expression of proteins was analyzed by 12 % sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE).

The supernatant was mixed and kept on a shaker with Talon resin (Takara, Japan) for about 1 hour following protocol of Immobilized Metal Affinity Chromatography (IMAC) method. After the sample was applied to the column, non-specifically bound proteins were removed with four- and six-times volumes of equilibrium buffer by 50 mM potassium phosphate buffer (pH 7.4) with/without 10 mM imidazole, respectively. And then, the bound protein was eluted with two times volumes of potassium phosphate buffer (pH 7.4) containing 200 mM imidazole. All samples were washed and concentrated by Amicon Ultra Centrifugal Filter (50 kDa MWCO) and were measured by the Bradford method. All the purified proteins were also analyzed by 15% SDS-PAGE.

2.2. Enzymatic assay

The purified proteins of CHS-like gene were prepared to verify the function of polyketide synthesis. The standard reaction mixture consisted of 0.5 mM starter-CoA, 1 mM malonyl-CoA, 200 µg of the purified recombinant *Senna* genus CHS-like proteins and 50 mM phosphate buffer (pH 7.4) in a total volume of 250 µl. The control reaction was conducted in a similar manner including *Senna* CHS-L and boiled protein. The reactions were incubated at 30 °C for 4 hours. Afterward, the reaction products were extracted by adding twice the total volume of ethyl acetate and shaking at 200 rpm for about 1 min. To separate the extract layer, centrifugation is performed at 13,000 rpm, and only the top layer is transferred to another tube. After evaporating all the upper solution using decompression concentration, dissolve the extract by adding methanol, filter it using a 0.22 µm filter, and use it for UPLC and MS analysis.

The reaction products were analyzed and quantified by Thermo UltiMate 3000 with Xselect HSS T3 (2.1 x 150 mm, 2.5 µm) connected to a PDA detector and electrospray ionization (ESI) mass source combined with Thermo U300-LTQ XL ion trap mass spectrometer (Thermo Scientific, USA). The flow rate is 0.3 mL/min and mobile phases A and B contained 0.1 % formic acid, water, and acetonitrile, respectively. Gradient elution was performed as follows: 5-100% B for 0-15 min with a linear gradient, followed by 5 min of 100% of B. The MS/MS system was operated in ESI mode. Mass spectra were acquired in the m/z range of 10-2,000 by applying three microscans and a maximum ion injection time of 100 ms. Data-dependent mass spectrometry experiments were controlled using mass control plug-in provided in MestReNova software.

2.3. Crystallization and structure determination

Recombinant proteins with approximately 95% purity were employed to generate protein crystals under various crystallization conditions using the sitting-drop vapor diffusion method at 22 °C. Initial crystallization conditions were further optimized to enhance crystal size and quality by adjusting specific parameters such as temperature, pH, and salt concentration. The optimal crystals were achieved by incorporating 0.08 M Tris-HCl (pH 8.5), 0.16 M MgCl₂, 24% (w/v) PEG 4000, and 20% (v/v) glycerol into the reservoir solution, with crystal formation observed after 2 days using the sitting-drop vapor diffusion technique. These protein crystals were then mounted in a

stream of cold nitrogen gas to prevent thermal damage during data collection on the BL-5C beamline at the Pohang Accelerator Laboratory (Pohang, Korea). Data processing was performed using XDS software [4]. For complex formation with CoA, a soaking method was employed, where the crystals were incubated with CoA dissolved in the crystallization buffer for 20 min at 22°C.

The phases of CHS-like protein coordinates were determined using the molecular replacement method with the MOLREP program from the CCP4i suite. The initial search model was based on the structure predicted by AlphaFold [5]. Following the initial round of refinement, difference density maps enabled the correct orientation of side chains to be incorporated into each structural model. The quality of the initial coordinates was further enhanced through iterative rebuilding and refinement using Coot [Emsley et al., 2010], REFMAC5 [6], and phenix.refine [7]. Final coordinates were validated for quality using MolProbity [8]. Structural representations were generated using PyMOL [9].

3. Results

3.1. Over-expression and protein purification of Chalcone synthase in *Senna occidentalis*

The full-length cDNA sequences of the CHS-L gene from *Senna occidentalis* were obtained through the genome information of *S.occidentalis*. Experiments were conducted according to PCR applications to obtain novel designed cDNA encoding CHS-L, and the cDNAs were expressed using an *E.coli* heterologous expression system following general experimental methods. A total of three genes were used in these experiments. Except for SocCHS-L1, the other two genes were easily expressed to obtain soluble protein, and the proteins, approximately 60 kDa in size (Figure 1A and 1B), were purified using IMAC (Immobilized Metal Chelate Affinity Chromatography) application (Figure 1C).

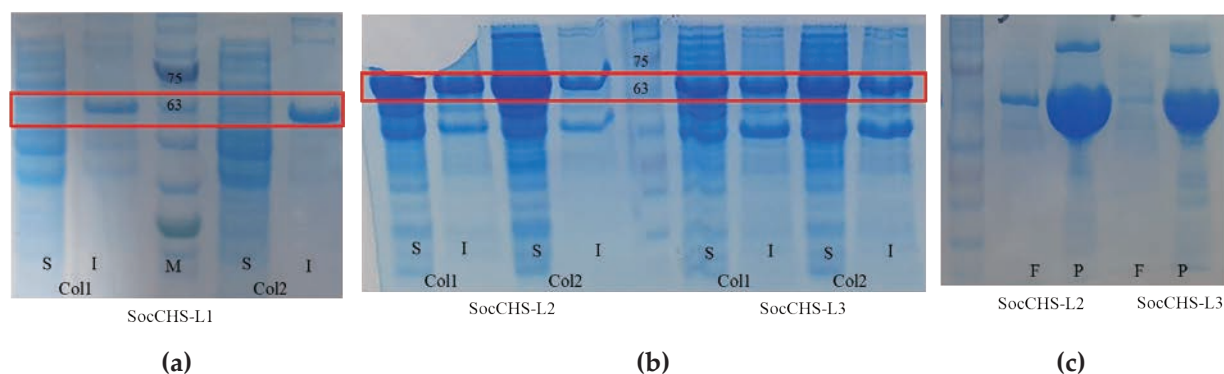


Figure 1. SDS-PAGE of *Senna occidentalis* CHS-L proteins: (a) Expression results of SocCHS-L1; (b) Expression results of SocCHS-L2 and SocCHS-L3; (c) Purification results of SocCHS-L2 and SocCHS-L3 (S: Soluble fraction, I: Insoluble fraction, M: Marker, F: soluble fraction, P: purified fraction).

3.2. Enzymatic assay and LC-ESI-MS/MS analysis

Type III polyketide synthase (PKS) usually uses aliphatic type CoA and aromatic type CoA as starter substrates and repeatedly polymerizes short-chain extender units such as malonyl-CoA to form intermediates. The start substrates and the number of polymerized units vary depending on the function and structure of type III PKS, which is why type III PKS produces a variety of products.

Acetyl-CoA and *p*-coumaroyl-CoA were used as starter units, and malonyl-CoA was used as the extender unit to react with SocCHS-L2. The reaction products were analyzed using the LC-ESI-MS/MS technique. The analysis revealed a product with an *m/z* value of 272, presumed to be *p*-coumaroyltriacetate lactone (CTAL), at approximately 8.91 minutes in liquid chromatograph of the sample using *p*-coumaroyl-CoA. And products with *m/z* value of 317 at 7.89 minutes and 299 at 9.22 minutes were observed in liquid chromatograph of the sample using acetyl-CoA (Figure 2). To confirm the exact structure of products, emodin and aloe-emodin, sharing the same anthraquinone scaffold, were analyzed under the same LC-ESI-MS/MS conditions. The MS/MS fragmentation pattern comparison confirmed that the products were atrochryson carboxylic acid and endocorcin anthrone at 7.88 and 9.22 minutes, respectively.

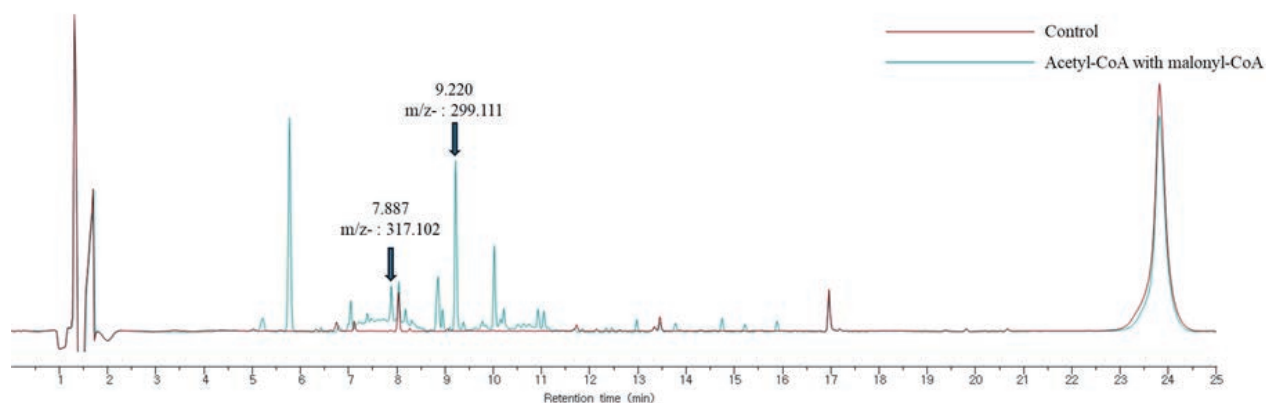


Figure 2. Liquid chromatogram of control (red) and reaction mixture of SocCHS-L2 (cyan).

3.3. Structure determination and comparison of SocCHS-L2 structure to other type III PKS

The crystal structure of SocCHS-L2 was determined by molecular replacement (MR) using homology modeling of AlphaFold [5]. From refinement, the crystal structure of SocCHS-L2 was determined at 2.1 Å. The structure of SocCHS-L2 is like that of homologous structures found in other species in terms of structural folds (Figure 3), with a unique structural topology that includes a specific upper domain ' $\alpha\beta\alpha\beta\alpha'$ ' (ketosynthase domain) [10], that is conserved in all structural homologs. The active site domain is composed of two twisted β -sheets surrounded by helices and separated by two long helices, H8 and H15. The CoA binding domain is composed of six helices (H1-H4, H9, and H10) and two strands (S9 and S10). The SocCHS-L2 protein is found in a homodimer state in solution, as indicated by SEC analysis. The dimerization interaction is primarily mediated by loops between S4 and H7, S5, H8, and S9, with a large interface area of 2169.2 Å².

The BlastP search using the SocCHS-L2 sequence against the Protein Data Bank (PDB) identified the top 5 analogues displaying high sequence similarity with both SocCHS-L2, each exhibiting over 50% similarity (Table 1). The results highlight that these homologues share similarities, particularly in the residues that constitute the active site and are highly identical to one another. However, specific distinctions in SocCHS-L2 merit particular attention. For instance, TrADS, the closest orthologue identified in the PDB, features a critical Tyr259 located adjacent to the active site triad, which plays a pivotal role in determining the size of the condensation pocket (Figure 4). Comparable confirmations of aromatic residues are observed in other homologues. Notably, in SocCHS-L2, the corresponding residue, Tyr264, is angled differently, interacting with water molecules and His211. This orientation of the Tyr264 side chain appears to be fixed, given that the hydroxyl group of Tyr264 forms a stable hydrogen bond with His211 – a unique interaction found only in SocCHS-Ls. Additionally, the residues Met130 and Met257 in TrADS are substituted with Ile136 and Gln262 in SocCHS-L2, respectively. These substitutions contribute to a larger condensation pocket in SocCHS-L2, measured at 274.1 Å³, compared to the undetectable pocket size in TrADS. Consequently, SocCHS-L2 is likely capable of facilitating reactions with multiple molecules of malonyl-CoA, leading to larger product sizes than those observed with TrADS.

Furthermore, a comparison of the pocket structure among SocCHS-L2, FhCHS1, and OsPKS revealed distinct conformations of the condensation pocket. While FhCHS1 and OsPKS share a similar pocket shape, positioned between the central two helices and the twisted β -sheets, SocCHS-L2 features a lengthy tunnel-like pocket directed towards the dimerization interface. A key distinguishing residue, Trp341, alters the shape and orientation of the pocket in these proteins. In SocCHS-L2, this bulky residue is stabilized by a T-shaped π -stacking interaction with Phe214 and is uniquely present only in SocCHS-L2 and TrADS. This suggests a unique mechanism in SocCHS-L2 for substrate condensation, distinguishing it from other homologues.

Octaketide synthase (ArOKS) derived from *Aloe arborescens* is a type III PKS known to produce octaketide as intermediates. We noted that SocCHS-L2 produces octaketides as intermediates similar to ArOKS and conducted a structural comparison analysis (Figure 5). We found that SocCHS-L2 has a total internal cavity volume of 411.25 Å³ and a total surface area of 389.33 Å², whereas ArOKS has an internal cavity volume and total surface area of 485.78 Å³ and 467.99 Å², respectively. Additionally, a comparison of the condensation pocket structures of SocCHS-L2 and ArOKS revealed that the two enzymes have different structural forms. ArOKS has a pocket formed

between two α -helices on the side of a twisted β -sheet, while SocCHS-L2 features a long tunnel-shaped pocket directed towards the dimerization interface.

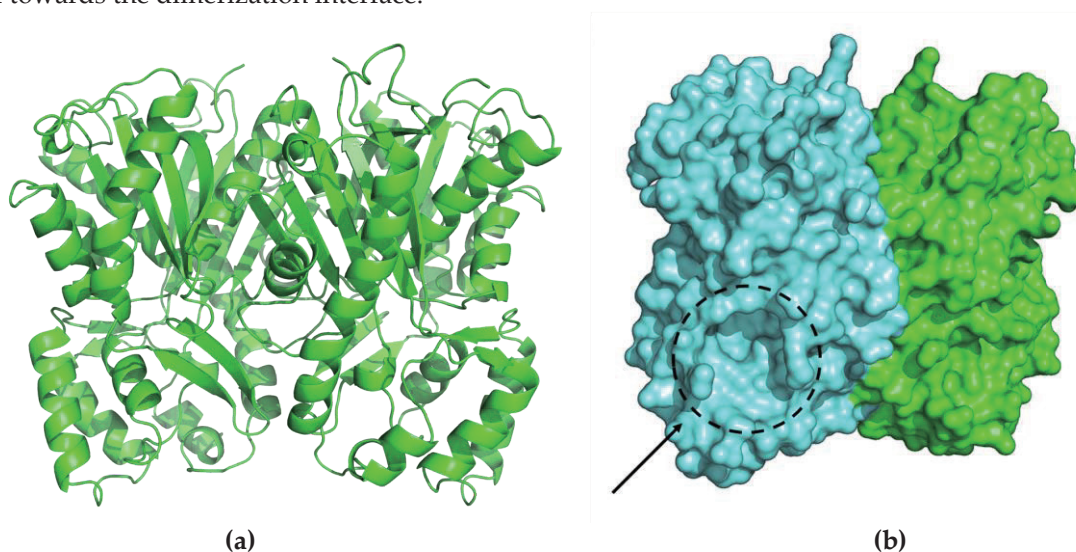


Figure 3. Overall structure of SocCHS-L2: (a) Overall views of dimeric structure of SocCHS-L2 represented with carbon; (b) Overall surface views of dimeric structure of SocCHS-L2.

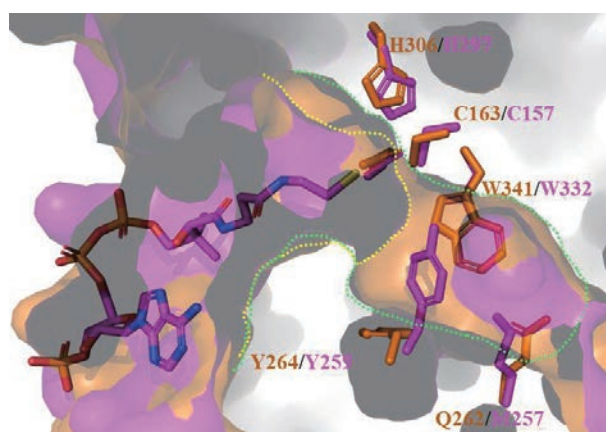


Figure 4. Comparison of the active site with other homologues. The structure of SocCHS-L2 (orange) is superimposed with TrADS from *Tetradium ruticarpum* (magenta, PDB ID: 5WX3).

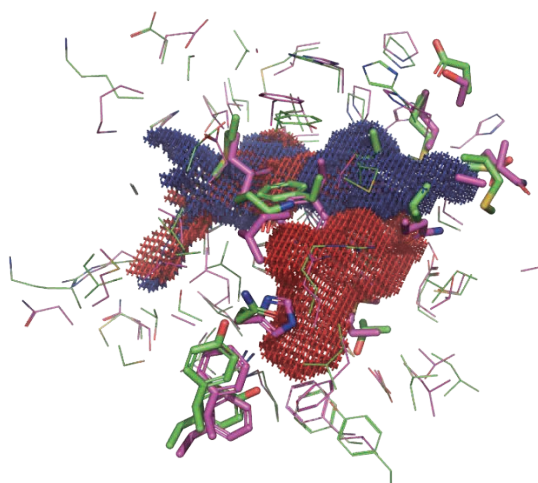


Figure 5. Comparison of internal cavity with SocCHS-L2 (Blue) and ArOKS (red). The OKS structure (purple) is superposed with SocCHS-L2 (green).

Table 1. This is a table. Tables should be placed in the main text near to the first time they are cited and should have a brief explanatory title

Rank	Description	Species	Query coverage	Per. Ident	Acc Len	PDB ID	Accession (uniprot)
1	TrADS	<i>Tetradiumruticarpum</i>	95%	55.94	396	5WX3	A0A1W7GKH6
2	FhCHS1	<i>Freesia hybrid cultivar</i>	95%	55.79	389	4WUM	G3FJ87
3	OsPKS	<i>Oryza sativa Indica Group</i>	96%	54.83	398	4YJY	A2ZEX7
4	AtCHS	<i>Arabidopsis thaliana</i>	95%	55.91	395	6DXB	P13114
5	MdCHS2	<i>Malus domestica</i>	95%	54.07	390	5UC5	K9MUA0

4. Discussion

Octaketide synthase (OKS) derived from *Hypericum perforatum* and *Aloe arborescens* is known as a type III PKS that produces octaketides in plants. Some researchers have speculated that these enzymes are involved in the anthraquinone biosynthetic pathway. However, both enzymes have only been shown to produce octaketides like SEK4 and SEK4b *in-vitro*, with no direct evidence of their involvement in anthraquinone biosynthesis.

A structural comparison between ArOKS and SocCHS-L2 revealed that, unlike other type III PKSs, both enzymes possess large internal pockets. Studies on ArOKS mutants have shown that these large pockets can accommodate more acyl units, facilitating the formation of larger condensation products. Despite this similarity, there are notable differences in the shapes of their internal pockets. ArOKS features a bent, large condensation pocket, whereas SocCHS-L2 has a long, tunnel-shaped pocket. This difference suggests that, while both enzymes can condense octaketide intermediates, the shape of their pockets may influence the intramolecular cyclization stage.

Through *in-vitro* reactions, we confirmed that SocCHS-L2 forms atrochryson carboxylic acid and endocrocin anthrone, which are precursors to emodin. Analysis of the crystal structure of SocCHS-L2 revealed not only a sufficiently large internal pocket to form octaketides, but also a tunnel-shaped pocket conducive to forming emodin precursors. This study provides deep insights into type III PKSs and enhances our understanding of the critical enzymes involved in the biosynthesis of anthraquinone compounds in plants.

Fundings: This research was supported by the project titled “Development of potential antibiotic compounds using polar organism resources (20200610)”, funded by the Ministry of Oceans and Fisheries, Korea. In addition, this work was supported by the MISP (Ministry of Science, ICT & Future Planning), Korea, under the National Program for Excellence in SW supervised by the IITP (Institute for Information & communications Technology Promotion) (Grant no. 2018-0-01865).

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Pathogen to plant- beneficial bacteria in *Burkholderia*

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Abstract: Microorganisms are known to inhabit various environments, and researchers have been striving to isolate microorganisms from numerous environments. With the advancement of sequencing technology, it is possible to perform sequencing analysis without isolating microorganisms, enabling the use of microbial genome information with various activities, and microbial research is becoming more active. In line with this trend of research, it was reported that there are various activities, and we wanted to study *Burkholderia*, which includes everything from pathogens to plant-benefit bacteria. *Burkholderia* has been steadily expanding and speciating since the initial speciation from *Pseudomonas*, and in the case of species related to pathogens such as *Burkholderia cepacia* complex, integrated research has been conducted in the form of complex. However, there is a lack of comparative research between different complexes and plant-benefic *Burkholderia*, so in this study, we compared pathogen and plant-benefic *Burkholderia* using genome information. The ANI analysis showed a significant difference, and the secondary metabolite pattern was also confirmed to be different. These results are expected to be the cornerstone for distinguishing pathogen and plant-benefic *Burkholderia* and subsequent research.

1. Introduction

Burkholderia was speciated from *Pseudomonas* and is one of the species that has been actively speciated until recently [1]. Currently, it forms a major axis with pathogen-related *Burkholderia*, plant-beneficial *Paraburkholderia*, and *Cabellonia* [2-4]. *Burkholderia* is composed of the *B. cenocepacia* complex (BCC), *B. pseudomallei* complex (BPC), and rice pathogenic complex, and papers on genomic diversity and classification are being reported. *B. sensu lato* encompasses several kinds of reclassified *Burkholderia* including *Paraburkholderia* and *Mycetohabitans*. More specifically, in the *Burkholderia*, which named *B. sensu stricto*, encompass BCC, BPC, and rice pathogenic *Burkholderia*. Recent studies on *Burkholderia* have underscored the application of genome-oriented classification [5], exploration of genomic diversity [6], and comprehensive genome analysis [7]. Following the introduction of genome-oriented classification of BCC, the taxonomic status of the inherent Taxon K has undergone reassessment [8]. Contemporary research has centered on the reclassification and comparative genomic analysis due to the influx of various genomes into databases. Investigations into genome-oriented classification, as well as secondary metabolites [9] and evolutionary comparisons [10] are feasible.

Despite ongoing genomic and metabolomic research on *Burkholderia*, studies on *B. sensu stricto* have been limited and have been treated as secondary aspects within the broader context of *B. sensu lato* research. This study aimed to understand the characteristics of the BCC and BPC complexes within *B. sensu stricto*. Unlike previous studies [1] that focused on the prevalence of BGCs according to individual genera within *B. sensu lato*, we conducted a more detailed analysis of BGCs within *Burkholderia*, considering species variation. Additionally, we aimed to elucidate the interrelationships between various species and metabolites through network analysis.

2. Materials and Methods

2.1. Preparation of *Burkholderia* genome

We retrieved 458 complete *Burkholderia* genome sequences from the NCBI database on February 17, 2023, and removed any duplicates [11]. The genomes were categorized into three groups based on strain isolation information from the NCBI and ENA databases, and their quality was assessed using CheckM and QUAST v5.2.0 [12]. For a comprehensive analysis, all genomes were annotated using Prokka [13]. We analyzed the Average Nucleotide Identity (ANI) using FastANI with default settings, and visualized the results using the ggplot2 package in R [14,15]. Genomes with over 80% similarity were selected for further analysis using FastANI. Referring to the

study by Wallner et al. [16], we analyzed genes listed as environmental-related genes and human virulence genes using blastp.

2.2. Secondary metabolite gene cluster analysis

We conducted a gene cluster analysis using the local version of antiSMASH [17]. Advanced analysis was performed using antiSMASH for comparison with the MIBiG database, and the output was subjected to network and phylogeny analyses using BiG-SCAPE and CORASON [18]. Known genes involved in BGCs were collected and confirmed using blastp. BiG-SCAPE was utilized for large-scale analyses and domain prediction, with sequence similarity calculations and pairwise distance measurements between BGCs forming the initial steps [19]. Statistical analysis for the basic genome was performed using QUAST, with multiple comparisons between species conducted using the Kruskal-Wallis test and post hoc Dunn test. Genome feature comparisons were performed using the Mann-Whitney test in R, with data visualized using the ggbetweenstats package.

3. Results and Discussion

To maintain data integrity, we implemented two exclusion criteria, removing duplicated samples and those not meeting completeness and contamination criteria as assessed by CheckM. We considered the frequent occurrence of genus expansion in *Burkholderia* and excluded samples with an ANI value below 83% as per fastANI recommendations. We confirmed 30 types of species, including BCC and BPC. Genome sizes of *Burkholderia* ranged from a minimum of 5.2 Gb to a maximum of 9.4 Gb, with GC contents ranging from 66% to 69%. Statistically significant variations of genome features were detected among the species, visualized using the length of the genome and GC content (Figure 1).

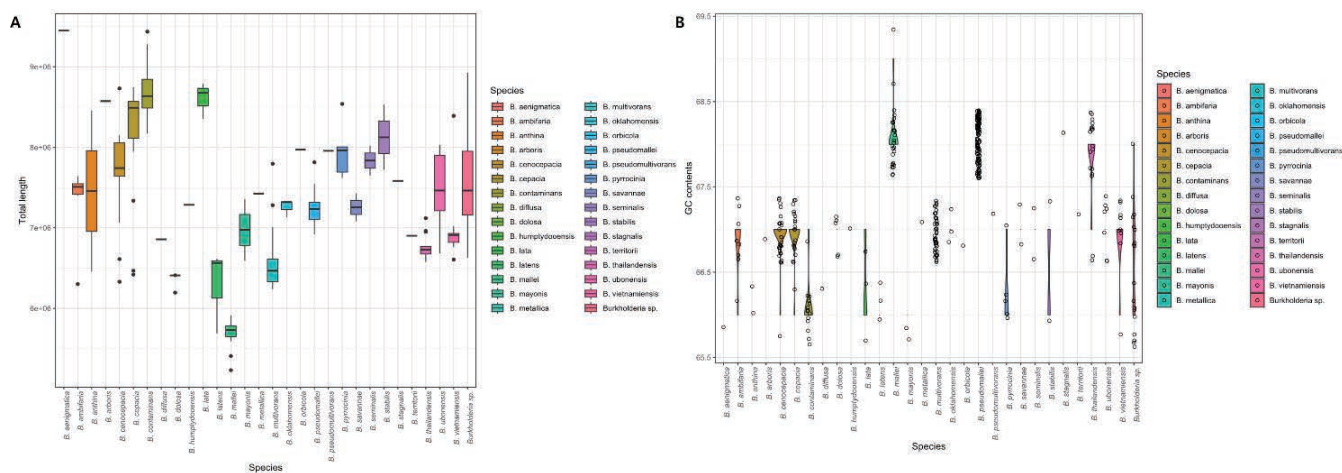


Figure 1. The statistics analysis of Genome size and GC contents in *Burkholderia*.

Using MLST, which analyzes based on specific genes, it was not possible to separate by species, and there was difficulty in analysis due to the lack of known genes in certain species. Figure 2 visualizes the MLST results through specific genes known in BCC and *B. pseudomallei*.

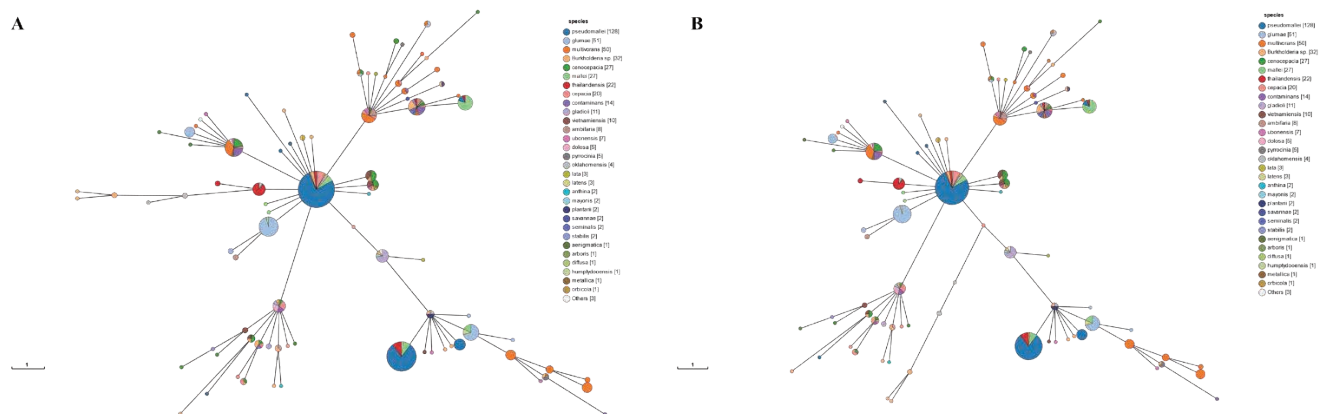


Figure 2. MLST results.

In the ANI analysis, strains that showed an identity of less than 83% included several species that have not been revised for speciation with rice-pathogenic *Burkholderia* (Figure 3A). We performed a pairwise ANI calculation on 366 *Burkholderia* species, which resulted in two distinct groups, A and B, based on the analysis (Figure 3B). Group A comprised of species such as *B. humptydoensis* and *B. mallei*, while Group B included *B. aenigmatica* and *B. ambifaria*, among others. The high similarity between *B. pseudomallei* and *B. mallei* was in line with previous findings [16]. The Mann-Whitney test was used to determine differences between the groups in terms of contigs, length, GC contents, and N50. Group B contained *Burkholderia cepacia complex* (BCC) species like *B. cepacia* and *B. multivorans* (Lipuma, 2005). Species with over 99% similarity were reclassified as similar species.

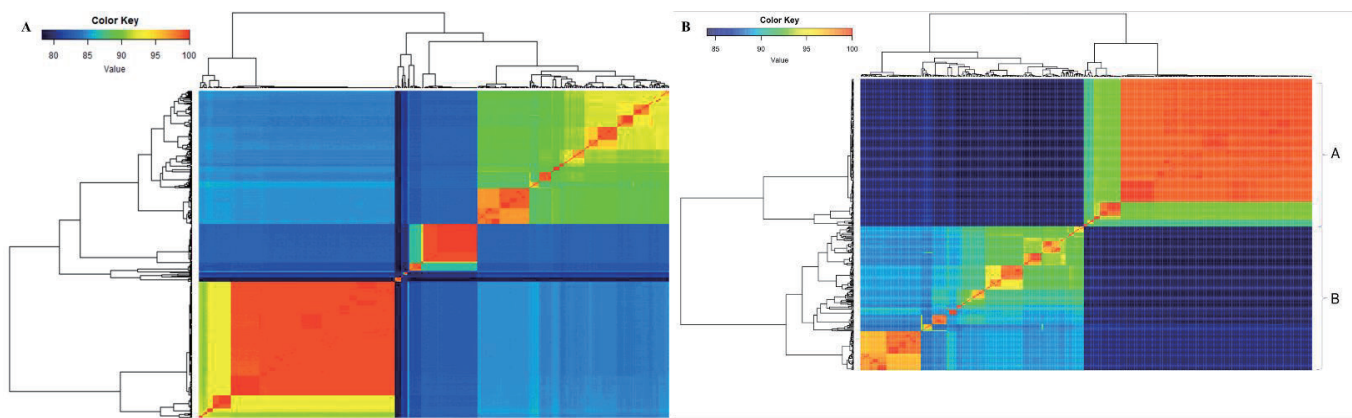


Figure 3. The results of ANI analysis.

We detected and categorized 6,666 Biosynthetic Gene Clusters (BGCs) into 30 classes using antiSMASH. Despite high similarity between *B. pseudomallei* and *B. mallei* in ANI results, they exhibited clear separation in the PCA analysis. We conducted network analysis on BiG-SCAPE results, categorizing antiSMASH outcomes into several classes. A total of 192 types of BGCs were found and compared with the MiBIG database. Despite the expected comparison of BGCs between *Burkholderia cepacia complex* (BCC) and *Burkholderia pseudomallei complex* (BPC) based on gene cluster similarity analysis and network analysis, a greater diversity of BGCs was observed (Figure 4). We predicted that complex and/or species would have different types of siderophore-related BGCs and conducted further analysis to explore siderophore gene clusters. Our study identified and categorized various secondary metabolites and Biosynthetic Gene Clusters (BGCs) across different *Burkholderia* species, revealing species-specific patterns and potential for distinguishing between BCC and BPC. This research expands the scope of genome mining of secondary metabolism in *Burkholderia*, offering a new direction for future studies.

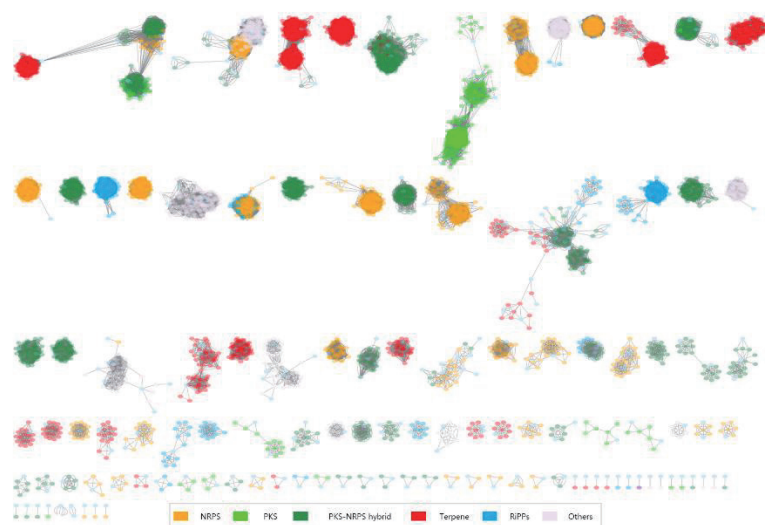


Figure 4. The visualization of network analysis.

4. Conclusions

This study aimed to analyze the features of *Burkholderia* species, categorizing them into BCC and BPC for analysis. Through network analysis, we found that each complex likely possesses a distinct pattern of Biosynthetic Gene Clusters (BGCs). We visualized the gene cluster of ornibactin, a siderophore found in the highest number of species, anticipating that pattern analysis could be further advanced. This research contributes to future studies on secondary metabolites in *Burkholderia*, despite the challenge of identifying novel BGCs.

Fundings: This research was supported by the project titled “Development of potential antibiotic compounds using polar organism resources (20200610)”, funded by the Ministry of Oceans and Fisheries, Korea. In addition, this work was supported by the MISP (Ministry of Science, ICT & Future Planning), Korea, under the National Program for Excellence in SW supervised by the IITP (Institute for Information & communications Technology Promotion) (Grant no. 2018-0-01865).

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Session 4

**Technologies
for Co-Prosperity**

The Case for Nuclear Power in the Transition to Net-Zero

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Abstract: Climate change due to skyrocketing concentrations of atmospheric greenhouse gases is driving an increased sense of urgency to transition away from fossil fuels to low-carbon sources of electric power. An international levelized cost of energy (LCOE) analysis shows the cheapest low-carbon source is extended life traditional nuclear, followed by hydro-electric, then solar and land-based wind at low grid penetration, with traditional nuclear not far behind. But variable renewable energy (VRE) sources such as solar and wind become more costly as their grid-penetration increases, as energy storage systems (ESS) must be added to mitigate intermittency. The cheapest ESS systems with sufficient daily throughput are lifted brick and above ground pumped water systems, but beyond a relatively low penetration threshold VRE+ESS become more rapidly more expensive with penetration than traditional nuclear or small modular reactors (SMRs). The latter are fission reactors designed to be stable to loss-of-coolant accidents, shorter time to operation, and are developing to the licensing and implementation stage. Although VREs are now all the rage, their ESS costs will tend to force international investments into lower cost base-loads like hydro and flexible SMRs as their grid penetration approaches their ESS cost barriers.

Keywords: climate change, nuclear power, variable renewable energy, small modular reactors, energy storage systems

1. Introduction

The industrial revolution that has brought so much benefit to mankind in terms of economic prosperity and convenience, has done it using mostly fossil fuels for the power that enabled it [1]. It is ironic that the blessings that allowed so many to avoid scourges of disease and poverty is now identified as the origin of a scourge all its own – greenhouse gas (GG) driven climate change. Its primary driver is the atmospheric accumulation of the long-lived molecule CO₂ born of burning fossil fuels [2].

Atmospheric CO₂ concentration has risen from around 276 ppm in the late 1700's, gradually from 1880 at about 3 ppm/decade, then accelerating in an exponential rise after the end of WWII [Ibid.] due to peace, prosperity and the demand for electricity, cars and oil (cf. [3, 4]). CO₂ is now over 400 ppm, well above range-bound oscillations of CO₂ between 180 and 300 ppm during ice-ages [5, 6]. We are now at levels last seen during the Pleistocene a few million years ago when trees existed in Antarctica [7]. At the same time the global mean surface temperature (GMST) has risen roughly 0.9^oC during the last 50 years to about 1.2^oC above pre-industrial era temperatures [2, 8, 9].

1.1 The greenhouse problem partly due to the abandonment of nuclear power

It is hoped “net-zero”, i.e., reducing fossil fuel consumption so there is “no net accumulation” of GG (especially CO₂) in the atmosphere, can be achieved by 2050. According to the IPCC the biggest world CO₂ producing sector in 2022 was energy systems (34%) followed by industry (24%), agriculture, forestry and land-use (22%), transport (15%) and buildings (5%) [10]. Electricity generation accounts directly or indirectly for 40% of all energy-related emissions [11]. Interestingly, Wagner noted [12] that the driver behind global energy consumption is population. Electric energy consumption vs population is shown in Figure 1, and fits well to a cubic. Data in Figure 1 shows that about 25500 TWh/y (i.e., about 2.9 TWe) is consumed presently, about 60% as coal and oil must be replaced. Extrapolating the cubic shows that by 2050 demand will rise to roughly 42000 TWh/y (4.8 TWe). This means about 3.6 TW of new power production must be supplied – 1.9 TW new, about 1.7 TW to be replaced, an average of 140 GWe/y over the next 26 years.

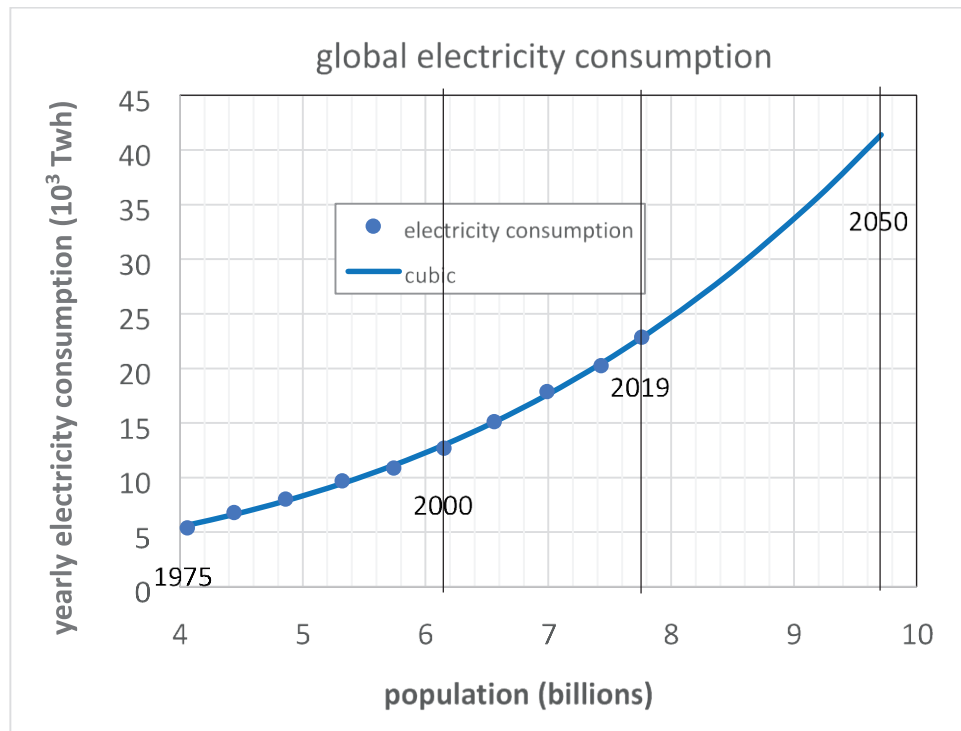


Figure 1. Electrical energy consumption as a function of world population data in the spirit of Wagner [12] using consumption data in years 1980 and after [13], and using [14] for population, the cubic is $(0.0458p^3 - 0.1227p^2 + 1.1359p) \times 10^3$ TWh, p in billions.

VRE seems to be quickly meeting that need. A surge of 500GWp rated capacity was built, mostly solar farms [15]. Considering capacity factors [16] that number is about 125 GWe considering. VREs will be added to low-carbon legs of hydro-electric and “traditional” nuclear comprising, respectively, 17% [17] and 10% [18] of total world electric power generation today. Yet, the specter of uncontrolled radiation release remains after loss-of-coolant accidents (LOCAs) at resulted in ruined reactors at Three Mile Island (TMI) in 1979 and Fukushima in 2011, and significant radiation release in the latter. These fears thwarted expansion of one of the existing legs of low-carbon power capacity - nuclear power – especially in Japan and the West. For the sake of the world this must be turned around.

1.2. The need for LOCA-safe designs

Technologies fail, and like airline accidents that cost lives, the industries learn and improve. This was certainly true following TMI [19]. And it is literally true that fatalities per TWh attributable to accidents in power production are lower by far for nuclear than in any other mode except solar [20]. But, a hundred-fifty thousand Japanese citizens were displaced after the Fukushima accident, and over 2000 deaths (most being of the vulnerable elderly) were attributed to displacement trauma [21]. By numbers alone the Fukushima disaster pales in comparison with over a million automobile accident deaths a year [22]; yet, response to the Daichi reactor failures and radiation release showed how deeply the fear of radiation is felt, as it brought a halt to nuclear projects in both Japan and W. Germany.

To move nuclear forward then, fission reactors must be made LOCA-safe. Fusion remains in a “research stage” and has a long way to go (see section 3.1). Remaining candidates are small modular reactors (SMR)s, and the well-known LOCA-safe design called molten salt reactors (MSRs), conceived by Eugene Wigner and later championed by his protégé Alvin Weinberg [23]. These also have passive shutdown, on-load refueling and waste removal, and the ability to burn waste thus creating much less of it.

While VREs are currently cheap, it will be shown that as penetration of the grid increases and energy storage systems (ESS) are increasingly deployed, diminishing returns as a function of VRE penetration will make VRE deployment more expensive than nuclear power beyond some VRE grid-penetration. Furthermore, nuclear is being actively pursued and built internationally where cost is significantly lower [24, 25], and promises to become cheaper still with faster project completion through SMRs.

2. Results

2.1. Nuclear fusion-hope deferred

Many readers might ask “what about nuclear fusion? Largely hidden from the public, however, are unresolved problems born of “fast-neutrons”, “high neutron fluxes” [26, 27] and intractable plasma instabilities [28]. And a tokamak reactor of the sizes contemplated for commercialization can actually explode from a “quench” fusion’s own version of a LOCA instability – destroying the reactor and vaporizing radioactive materials generated from those high neutron fluxes. These problems along with the incredible size and cost of the tokomaks has caused at least one researcher to conclude current tokomak fusion projects will never lead to commercialization [29].

2.2. Solving the LOCA instability problem

2.2.1. Molten Salt Reactors

The idea of fission reactors based on molten thorium fluoride salt came out of Oak Ridge National Laboratory, and was championed by Alvin Weinberg, its director from 1955 to 1973. Fluoride salts of actinide fuels are stable at high temperatures and in molten form can be used as both coolant and the carrier of fuel. The LOCA-safe mechanism involves a salt plug that is actively kept frozen such that if a cooling circuit is broken that causes the primary or secondary pumps to fail the plug melts, spilling the contents into sub-critical tanks below. Thorium is particularly helpful in that it cannot be weaponized.

Not using water as a moderator and coolant as light water reactors (LWR) do avoids the possibility of steam explosions and a buildup and explosion of hydrogen gas which happened in both TMI and Fukushima, and led to the exposure of core and radiation leak in the latter. This led to regulations ensuring ignitors and passive autocatalytic recombiners are installed in all LWRs to avoid such incidents [30].

Unfortunately, the molten salts corrode and weaken materials, and would tend to disqualify it as a transition candidate at this time; however, improving corrosion resistance in MSR remains an active field of research [31].

2.2.2. Advanced Reactor Designs - the Small Modular Reactor

SMRs promise to change the calculus of safety, flexibility, and ultimately cost of nuclear fission. SMRs are stable to a LOCA, i.e., their smaller size, ceramic fuel cladding, and passive cooling design prevent damage following a LOCA. In the absence of a site blackout (SBO – cf. [30]) SMRs are “walk-away safe”. The IAEA “SMR book” details 56 SMRs and 6 “micro-reactors” (10 MW or less) of various styles, mostly in various stages of development, though 4 are operational, 4 under construction, and 6 in pre-licensing or review stage [32].

2.3. The cost calculus of electrical-grids undergoing transition to net-zero

We examine levelized cost of energy (LCOEs) analyses to compare power alternatives, especially traditional nuclear, SMRs, solar and wind, with and without costs of ESS. In Figure 2 are plotted median costs from a set of LOCE analyses at a 3% discount: the International Energy Agency (IEA) [33] using international data for nuclear cost, another from Lazard [34] using just US data for nuclear, solar and wind, and a third [35] based on Australian grid data [36] which enables comparison with the other LCOEs by including costs of ESS for high VRE penetration. SMRs are included through other estimates [37-39] for comparison. IEA’s 3% discount rate was selected in a best-effort to match to Lazard’s solar and wind.

The cheapest cost for energy is to extend currently deployed nuclear at \$30/MWh. Then hydro (river and reservoir), then solar and land-based wind, traditional nuclear, and SMRs. Lazard’s numbers come in higher, especially for nuclear, revealing a stunning international cost disparity explored further in section 3.4.

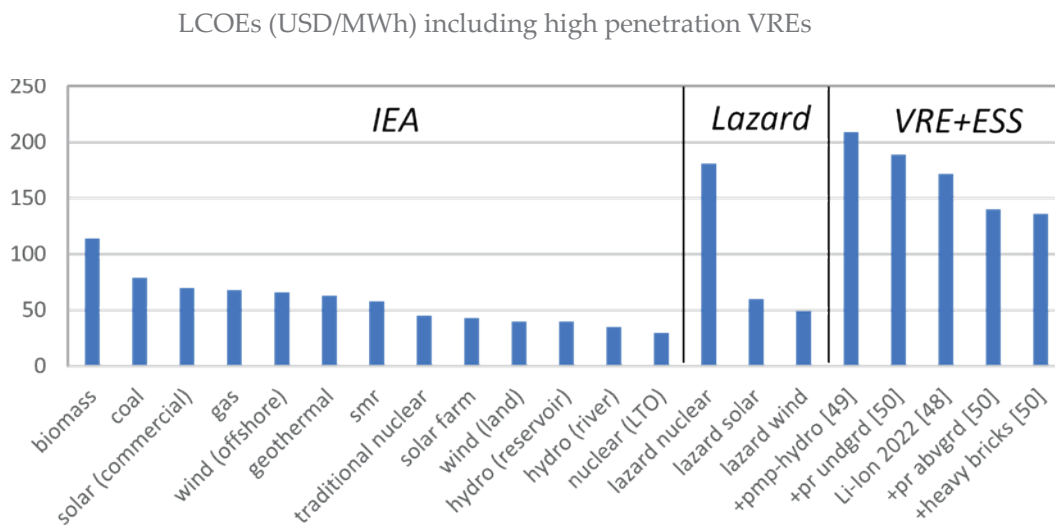


Figure 2. Median LCOEs at 3% discount rates from IEA obtained from 24 countries [33], where SMR bars are estimated using data from [37 - 39], Lazard [34] and Osmond [35] using OpenNEM [36]. High VREs are extremely costly, extended traditional nuclear is cheapest. Lazard’s data based on US costs imply national and legal culture is significant.

The picture changes dramatically at VRE penetrations when ESS is included. Examining the Australian grid, Osmond [35], using data from OpenNEM [36] with an optimal 4:3 solar to wind mix, analyzed high VRE penetration including ESS cost for daily throughput at 15GW for 4-hour (i.e., short term) storage. Median costs ranged from \$136/MWh for heavy bricks, to 172 \$/MWh for Li-Ion storage to \$209/MWh for pumped hydro (actually computed for 6-hr storage). Interestingly, above ground pumped water came in at \$140/MWh. Still, these numbers are three and four times a \$42/MWh 4:3 solar mix computed from IEA’s numbers. It seems to imply penetrations of only a few percent are cost competitive with nuclear, and not with hydro at all.

2.4 Per country cost and completion times

In Figure 3 costs and project completion times, are shown to be are much lower outside the US.

US costs after TMI are 4x before it, completion time 6x Japan’s. It was noted in Figure 2 that the Lazard LCOE estimate for nuclear was skewed due to its reliance on US nuclear data alone, and Figure 4a shows what is behind that. It seems clear that nuclear history or technology alone does not determine cost or time to completion; rather, it is commonly per-country legal and regulatory (and possibly even cultural) frameworks causing differences.

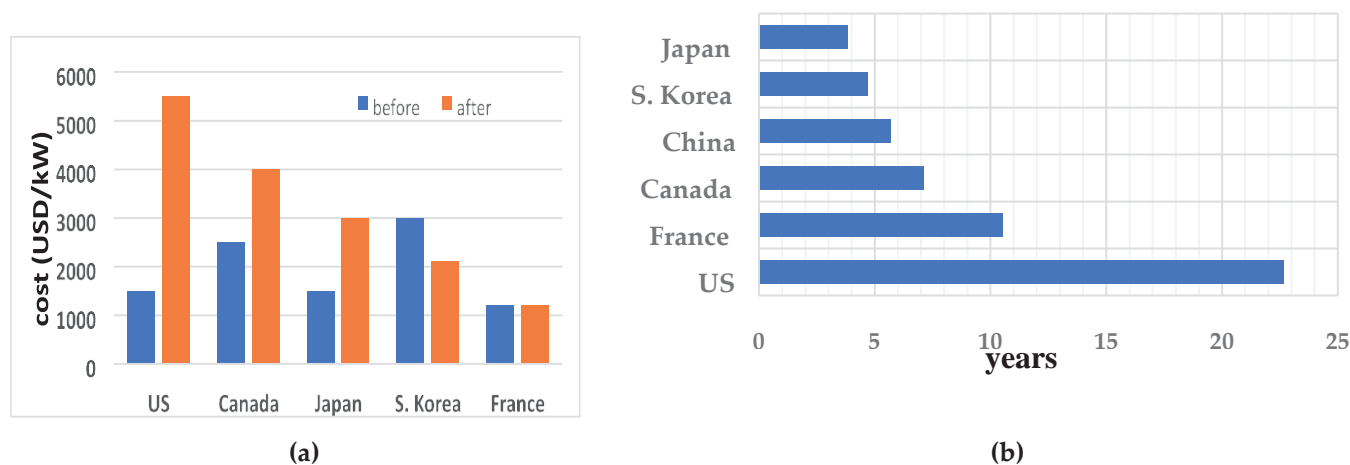


Figure 3. (a) Per-country cost history for nuclear [40]. Before/after for US is TMI, for Canada is 1980, Japan is 1975, S. Korea is 2000, France stayed roughly constant; (b) Time for project completion [24, 41]; US is 5x that of S. Korea.

3. Discussion

There are many issues not covered to keep the paper with conference limits, such as waste disposal which deserves its own manuscript. Regarding the latter, both nuclear and solar waste are toxic. The former is well handled through vitrification [42] but faces “not-in-my-backyard” resistance for permanent storage; the latter constitutes 50x the mass [43], and 300x the volume [44] of nuclear for the same power output and will leak toxic chemicals over time [45]. That must be addressed. Solar and wind have insurability issues due to severe weather that may be caused by, guess what, the very climate change they are trying to address [46].

Climate change is a worldwide problem that requires a re-thinking of all energy consumption, and the electric grid, in particular. At COP28 - the recent UN climate change conference in Dubai - 197 countries included nuclear in a list of low-carbon technologies that they acknowledged needed to be “scaled up” [47]. This led Rafael Grossi, the director of the International Atomic Energy Agency, to remark, “I don’t think that this a renaissance of nuclear, but a return to realism. The International Panel on Climate Change, which is a gathering of the greatest and the brightest scientists from all over the world studying climate issues, has recognized that, without nuclear energy, it will be almost impossible to decarbonize by 2050” [47].

We see hydro and nuclear baseloads together with a mix of VREs as the future of the grid. To proceed along a path that minimizes long-term cost (including sufficient ESS to balance VREs), yet retains a solid baseload which is the foundation of electrical grids, nuclear licensing and buildout should proceed quickly pointing to SMRs as the safest reactors of choice at this time.

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Battery cell temperature compensation monitoring operation

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Abstract: As electric vehicles spread, electric vehicle fires continue to occur. The main cause of these electric vehicle fires is battery overload caused by battery management system (BMS) malfunction. Existing BMS measures the voltage of the battery by physically connecting each battery cell and the controller, but in electric vehicles, the battery operates up to 1,000V or more. In this high-voltage environment, the BMS, which is the circuit that manages the battery, operates at a low voltage of 5V or less. Therefore, if a high battery voltage has an incorrect effect on the BMS board operating at a low voltage, the BMS board is destroyed, leading to battery malfunction and battery explosion. In order to compensate for these problems, indirect measurement technology that physically isolates the battery cell and the low-voltage control board is important. The indirect measurement method of the isolation structure obtained in previous research for safe battery voltage measurement resulted in battery cell voltage monitoring results of several mV to tens of mV due to errors due to device imbalance and temperature characteristics of the battery cells found in the parallel structure. To solve this problem, we were able to overcome inaccurate battery cell voltage monitoring results due to device imbalance and temperature characteristic differences at once by sequentially monitoring the battery voltage of all battery cells through a single indirect measurement path. In the process of recognizing battery cell voltage, changes in monitoring voltage depending on temperature must be compensated. However, the existing temperature compensation circuit used a temperature sensor to compensate for the temperature with a resistance value, but accurate compensation was difficult. In this paper, in order to accurately compensate for temperature, the reference voltage (REF_V) was created internally by dividing it into 15 steps from 4.2V to 3.2V, and the temperature can be compensated by applying the voltage (REF_V), so the battery voltage can be recognized accurately at any temperature. I could do it. Additionally, the internal clock oscillator that generates the clock internally is designed to operate at 1kHz. As a result of the design, temperature compensation was performed on 16 battery cells, and when operating at an internal clock of 1kHz, all 16 battery cells and reference voltages could be monitored in 2 seconds. The research results of this paper automatically generate temperature compensation. voltage REF_V and battery cell voltage along with code values, allowing BMS operation to be accurately known without CPU control.

Keywords: Monitor, Battery, Temperature, Compensation, BMS, Reference voltage

1. Introduction

The importance of battery management systems (BMSs) has been emphasized as the prevalence of electric vehicles increases. The BMS monitors the status of each battery cell in real time to prevent risks such as overcharging, over discharging, and thermal runaway [1]. It plays an important role in extending the life of the battery, increasing its safety, and improving the efficiency of the overall system [2]. Existing products are being made wirelessly with convenience [3]. However, the existing BMS requires proper isolation to prevent interference between the high voltage and low voltage systems because the battery and control are directly connected, which can affect the low voltage operating BMS circuit and cause malfunction or damage. To solve this problem, an indirect measurement technology that physically isolates the battery cells and the low voltage control board using LEDs was proposed in previous studies to isolate the battery and the BMS, preventing the high voltage battery from affecting the BMS. However, a voltage recognition error occurred due to the difference in characteristics of each element when using multiple LEDs. This is because the characteristics of the LED vary depending on the manufacturing process, temperature, current, etc. To solve this problem, this paper proposed a technology that monitors all battery cell voltages with one LED with a multi-cell single-path. It is a method of measuring the voltages of multiple battery cells sequentially. In this way, it is possible to accurately monitor without any error due to the

difference in characteristics of each element. In addition, we designed a circuit that generates a high resolution reference voltage to solve the monitoring voltage error caused by changes in the environment.

By performing a temperature compensation algorithm based on the generated reference voltage, monitoring errors caused by temperature and voltage changes can be overcome to ensure accurate BMS operation.

2. Materials and Methods

2.1. MULTI-CELL SINGLE-PATH BMS DESIGN

Figure 1. shows the battery voltage monitoring structure that monitors multiple cells in a single path in the proposed isolation structure. The reference voltage generated by REF VOLTAGE BLOCK is input through REF_VOLTAGE SWITCH ARRAY BLOCK, the battery cell voltage is input through BATTERY CELL SWITCH ARRAY BLOCK, and the voltage is monitored sequentially through the sequential signals generated by CODE GENERATION BLOCK. The voltages selected sequentially are designed to perform monitoring operation with one output by receiving the SEL_BAT signal generated by CODE GENERATION BLOCK and selecting the reference voltage or the battery cell voltage.

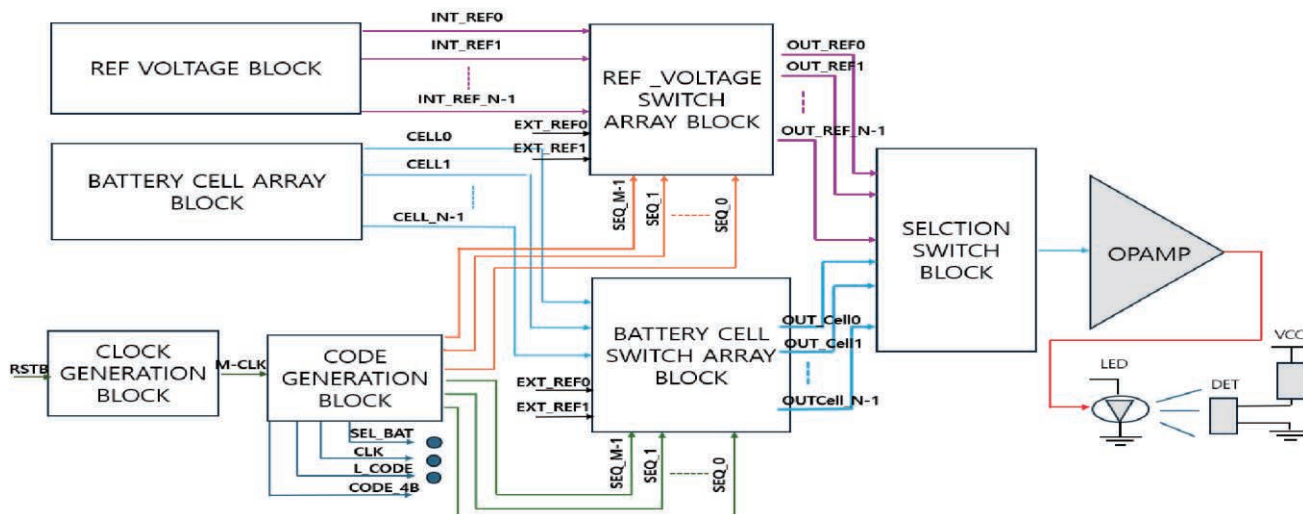


Figure 1. Proposed isolation battery voltage monitoring structure (Single-Path Multi Cell).

2.2. HIGH RESOLUTION REFERENCE VOLTAGE CIRCUIT DESIGN

The existing technology is implemented as a BGR (bandgap reference) circuit to obtain a reference signal [4]. However, the BGR technology is a technology that obtains one reference signal and has a limitation in temperature compensation by comparing several voltages.

Therefore, it is necessary to compensate for the temperature by obtaining several reference signals between 3.2V and 4.2V, which are battery cell voltages [5]. The battery cell voltages technology designed a reference signal circuit based on current control, but it was difficult to obtain the voltage required for the battery cell voltage. Therefore, in order to obtain multiple reference signals in the required voltage range, a plurality of reference signals can be generated through a resistance array, but in this paper, a plurality of reference signals are selected based on a core circuit that obtains array reference signal, and a plurality of reference signals are selected by a coarse decoder and a fine decoder so that the reference signals close to the desired battery cell voltage can be quickly and accurately obtained and the temperature can be compensated. Figure 3 shows a block diagram of the high resolution reference voltage ip reflecting these contents.

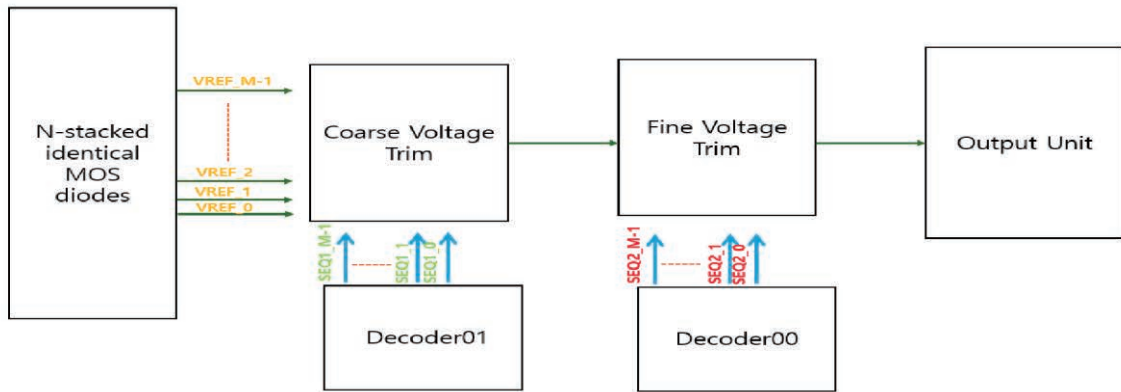


Figure 2. HIGH RESOLUTION REFERENCE VOLTAGE's IP BLOCK DIAGRAM.

2.3. TEMPERATURE COMPENSATION ALGORITHM

Figure 3 shows the Temperature Compensation Algorithm Flowchart. After reading the battery cell voltage and the reference voltage, the reference voltage is compared to find the closest value and the temperature of the battery cell voltage can be compensated based on the reference voltage.

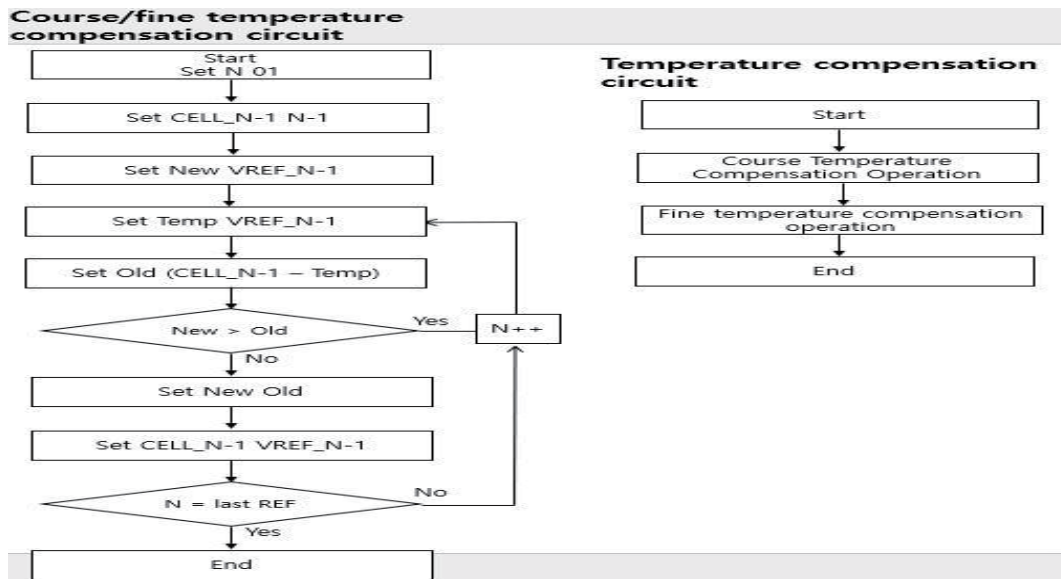


Figure 3. Temperature Compensation Algorithm Flowchart.

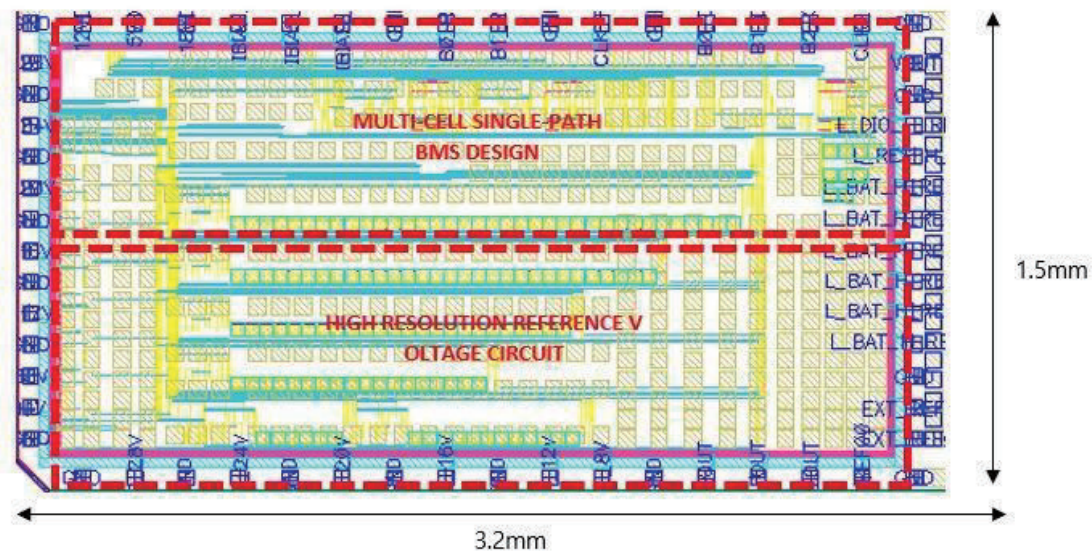


Figure 4. Designed layout drawing.

3. Conclusions

This paper proposed and implemented a circuit to reduce environmental and device errors in order to monitor accurate battery voltage. A multi-cell single-pass sequential circuit was implemented to reduce device error, and a tr-array-based high-resolution reference voltage was obtained to implement a temperature compensation circuit to reduce environmental error, and the algorithm was performed with coarse and fine operations. Since the reference voltage operates in 3mV resolution and the battery cell voltage operates based on this, the battery cell voltage could be accurately monitored with an error in 3mV. Figure 4 is a designed layout drawing.

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A 60 GHz Low Power and High Gain Variable Gain Amplifier

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Abstract: We introduce a compact 60-GHz variable-gain amplifier optimized for high efficiency and wireless applications, crucial for combating climate change and advancing automation. This device features a phase-compensated variable array attenuator in a four-stage common-source layout, using advanced 65-nm CMOS technology. It achieves a peak gain of 30.2 dB with a gain control range of 3.2 dB to 30.2 dB, supporting broadband needs for automated and wireless automotive systems like rear-view cameras. The design's phase stability is enhanced by a proprietary technique, limiting phase variation to under 5 degrees. It also maintains low power consumption at 42.3 mW, supporting sustainable technology use. Performance tests show strong reliability, with consistent scattering parameters across various conditions, making it ideal for modern, energy-efficient wireless communication in automation and vehicle applications.

Keywords: CMOS, Attenuator

1. Introduction

In recent developments in high-frequency amplifier technology, considerable advancements have been made in designing variable gain amplifiers (VGAs) that effectively manage phase errors during gain adjustments, which are crucial for the burgeoning needs of modern wireless communication systems. Park et al. [1] aim to minimize phase errors, crucial for wireless communications, yet face limitations in phase control. Lee et al. [2] explore a 60-GHz phased-array transmitter incorporating phase-compensated VGAs to tackle the challenges posed by gain variations in phase shifters and to facilitate non-uniform amplitude distribution across array elements. But still, it has some limitations in Gain control. Li et al. [3] presented a VGA using 90-nm CMOS that maintains consistent phase characteristics, important for high-data-rate systems. In comparison, our design is tailored for applications like automated vehicle systems, overcoming fixed gain and phase limitations with adjustable settings via NMOS arrays. Zhiming et al. [4] explore low-power VGAs that use different degeneration techniques to balance gain and bandwidth, though these also have fixed gains. We proposed a 60-GHz VGA with a 3.2 to 30.2 dB gain range that plays a pivotal role in emerging technologies such as 6G, demanding precise control over signal direction and amplitude [5]. Our VGA's adaptability through an NMOS transistor array aligns with the needs of automotive applications, enhancing connectivity and safety in dynamic environments. This approach supports the efficiency and flexibility required by next-generation wireless technologies.

2. Circuit Design

Our design employs a unique phase compensation technique that maintains phase stability within 5 degrees, ideal for high-frequency applications while ensuring efficient power usage, as demonstrated in our scattering parameters analysis. These advancements offer a robust solution for high-performance communication systems and phased-array antennas.

Figure 1 introduces a 60-GHz VGA with a phase-compensated variable array attenuator, enhancing RF amplification standards. Our design uses an NMOS transistor array to dynamically adjust gain and phase, enhancing the reliability and precision of beamforming in AV. This adaptability ensures stable communication, critical for navigation and real-time data processing in AV systems, aligning with the advancements in next generation wireless technologies focused on efficiency, accuracy, and flexibility. This architecture combines a four-stage common-source amplifier with an array attenuator, built using a 65-nm CMOS process.

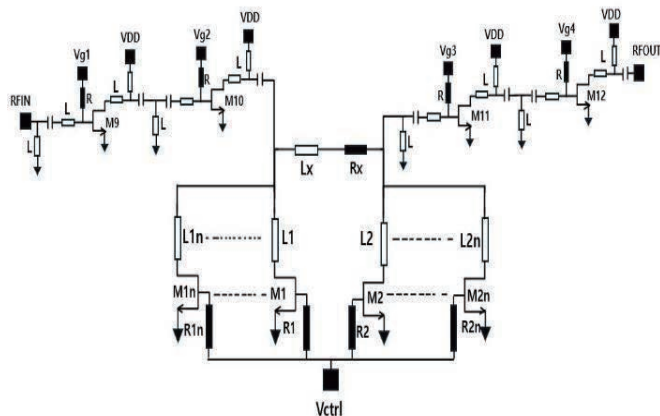


Figure 1. Proposed VGA.

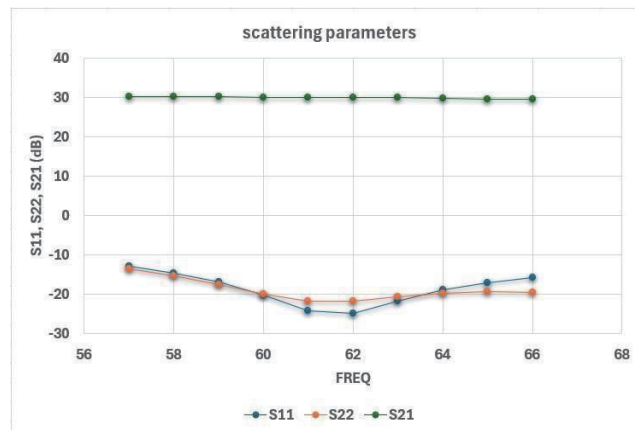


Figure 2. Proposed VGA S-Parameters.

3. Results

Figure 2. illustrates the scattering parameters of a VGA, S11 ranges from -12 dB to -25 dB, S22 from -13 dB to -21 dB, and S21 from -30.2 dB to 29.1 dB. Compared to papers [1] and [4], our data shows superior scattering parameters.

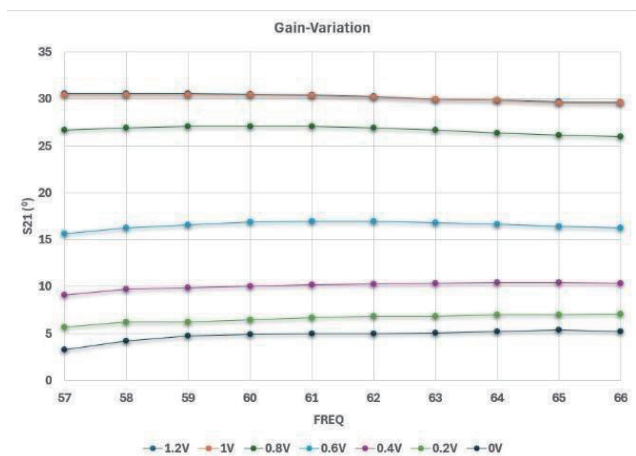


Figure 3. Proposed VGA gain-variation.

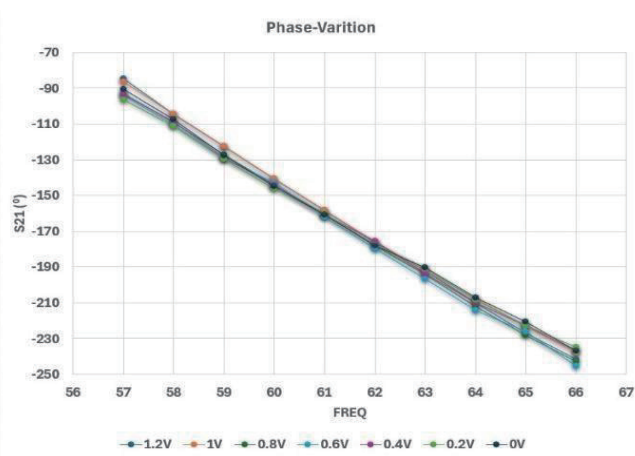


Figure 4. Proposed VGA phase-variation.

Figures 3 and 4 demonstrate superior performance in VGAs with a peak gain of 30.2 dB, managed over a range from 3.2 dB to 30.2 dB. Our unique phase compensation maintains phase variation within 5 degrees and consumes only 42.3 mW of DC power. Meanwhile, other studies, as shown in Table 1 majority have the high phase error and low gain variation with high power consumption. Our VGA's blend of high gain and precise phase control means no limitations of gain and phase variation making it ideal for demanding high-frequency applications, especially the future automotive vehicles.

Table 1. Comparisons Table

S.NO	Our Work	[6]	[7]	[8]
Process	65 nm	65 nm	65 nm	65 nm
Topology	ATT-Array VGA	Impedance compensation	variable-gain and variable-bandwidth	bi- directional VGA
PDC(mW)	42.2	45	98.46	67
Gain(dB) Peak	30.2	12	17.6	15.6
Δ Gain(dB)	3.2 to 30.2	-10.5 to 12	5.2 to 17.6	12
Phase($^{\circ}$)	< 5	< 2.3 RMS	NA	< 6.1

4. Conclusions

In conclusion, our newly developed 60-GHz variable-gain amplifier represents a significant advancement in RF technology. It integrates a four-stage common-source amplifier with a phase-compensated variable array attenuator, achieving high gain, extensive gain control, and exceptional phase stability. Built using 65-nm CMOS technology, it offers a peak gain of 30.2 dB and a gain range of 3.5 to 30.2 dB. A novel phase compensation technique limits phase variation to just 5 degrees, enhancing signal consistency and integrity. Additionally, the amplifier's low power consumption of 42.3 mW makes it ideal for power-sensitive applications. Tests of scattering parameters confirm the circuit's robustness and effectiveness, surpassing existing RF performance standards and setting a new benchmark for future innovations.

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Development of a Color Classification System Using TCS3200 Color Sensor with an Optimized Integrating Sphere

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Abstract: This study developed an innovative color classification system integrating the TCS3200 color sensor with an optimized integrating sphere to enhance color recognition accuracy in varying light conditions. The system features a curved baffle and titanium white coating, which optical simulations showed improved light uniformity and increased overall sensitivity compared to conventional designs. An Arduino-based control system with servo motors automates the classification process. Experimental results demonstrated the system's capability to process about 5 objects per minute with an average RGB similarity of 74.06% across 12 color samples. The integrating sphere's design significantly reduced sensitivity to external lighting variations, maintaining consistent performance under diverse conditions. This research contributes to the field by proposing a novel method to substantially improve color sensor performance, particularly in industrial applications requiring high accuracy and consistency. The system's stability and accuracy make it potentially valuable for applications in food industry, recycling, and quality control, addressing the limitations of conventional color detection systems in dynamic lighting environments.

Keywords: TCS3200 sensor, integrating sphere, curved baffle, titanium white coating, color classification, automation system, optical simulation

1. Introduction

Color classification plays a crucial role in various industrial sectors, particularly in food, pharmaceutical, and recycling industries, where accurate color recognition and sorting are essential for quality control and productivity enhancement. However, conventional color detection systems often suffer from sensitivity to external lighting conditions, limiting their accuracy and consistency. This study proposes a novel approach by combining a color sensor with an optimized integrating sphere to address these limitations [1-4].

2. Materials and Methods

2.1. System Design

The developed system consists of three main components: (1) a color detection module comprising the TCS3200 sensor and an integrating sphere, (2) an Arduino-based control system, and (3) a servo motor-driven mechanism for object transportation and sorting [5].

2.2. Integrating Sphere Design and Simulation

We utilized LightTools software for optical simulations to optimize the integrating sphere design. The simulations focused on optimizing parameters such as sphere size, internal reflectance, sensor position, and most notably, the introduction of a curved baffle.

The optical simulations focused on light distribution, colorimetric analysis, and color recognition capabilities of our system. We used the simulation results to generate cross-sectional views, luminance distribution models, Commission Internationale de l'Eclairage (CIE) 1931 chromaticity diagrams, and color detection visualizations.

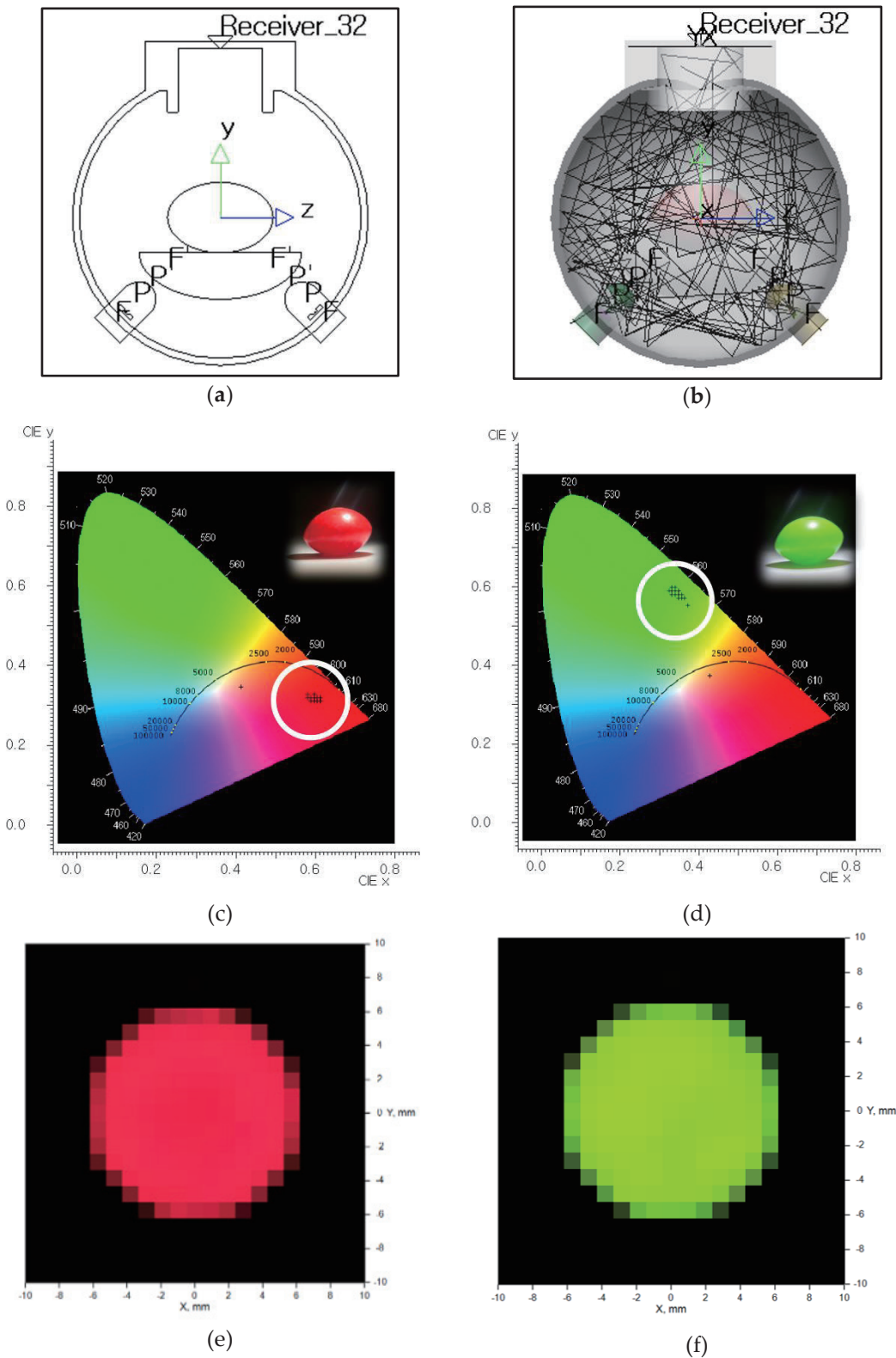


Figure 1. Optical simulation results: (a) Cross-sectional view of the integrating sphere with curved baffle; (b) Luminance distribution simulation; (c,d) Simulated CIE 1931 chromaticity diagrams for red and green color samples respectively; (e,f) Simulated color detection visualizations for red and green samples.

The cross-sectional view (Figure 1(a)) shows the design of our integrating sphere with a curved baffle, which is crucial for uniform light distribution. The luminance distribution simulation (Figure 1(b)) demonstrates how light intensity is distributed within the sphere.

The CIE 1931 chromaticity diagrams (Figures 1(c) and 1(d)) illustrate the color recognition capabilities of our system for red and green samples. These diagrams show how accurately our system can identify and represent different colors within the visible spectrum.

The color detection visualizations (Figures 1(e) and 1(f)) provide a clear representation of how our system perceives and processes red and green color samples. These visualizations demonstrate the system's ability to accurately detect and differentiate between distinct colors.

2.3. Integrating Sphere Coating

A key innovation in our design was the use of titanium white coating for the integrating sphere's interior. This coating was chosen for its high reflectance across the visible spectrum and its durability. The titanium white coating contributes to improved light distribution and long-term stability of the system.

Table 1. Optical properties of integrating sphere interior and baffle (Unit: %)

Scattering Wavelength	450nm (Blue)	550nm (Green)	650nm (Red)
Absorption	5	5	5
Transmission	95	95	95
Reflection	100	100	100
Diffuse Reflection	95	95	95
Specular Reflection	5	5	5
Transmittance	0	0	0

- (a) Integrating sphere interior and baffle: Lambertian scattering is applied, and wavelength-dependent absorption/reflection/transmission characteristics are defined as in Table 1 to simulate the titanium white color of the integrating sphere interior and baffle in the simulation.
- (b) Sensor housing: Black matte coating (95% absorption) or white matte coating (95% reflection) was set as simple reflection and simple absorption.

Table 2. Optical properties of red candy (Unit: %)

Scattering Wavelength	450nm (Blue)	550nm (Green)	650nm (Red)
Absorption	95	95	5
Transmission	5	5	95
Reflection	100	100	100
Diffuse Reflection	95	95	95
Specular Reflection	5	5	5
Transmittance	0	0	0

Table 3. Optical properties of green candy (Unit: %)

Scattering Wavelength	450nm (Blue)	550nm (Green)	650nm (Red)
Absorption	95	5	95
Transmission	5	95	
Reflection	100	100	100
Diffuse Reflection	95	95	95
Specular Reflection	5	5	5
Transmittance	0	0	0

2.4. Color Recognition Algorithm

The color recognition process involves the following steps:

Normalization and inversion of sensor readings:

$$R = 255 * (1 - (f_{red} - f_{min}) / (f_{max} - f_{min})) \quad (1)$$

where R is the red value, f_{red} is the sensor frequency for red, and f_{min} and f_{max} are calibration values. RGB to HSV conversion and correction:

$$H' = H + \text{hue_offset} \quad (2)$$

$$S' = S + \text{saturation_offset} \quad (3)$$

$$V' = V + \text{value_offset} \quad (4)$$

3. Results

3.1. Color Recognition Performance

The system demonstrated an average RGB similarity of 74.06% across 12 different color samples. The RGB similarity was calculated using:

$$\text{Similarity (\%)} = (1 - \sqrt{[(R1-R2)^2 + (G1-G2)^2 + (B1-B2)^2] / (3 * 255^2)}) * 100 \quad (5)$$

where (R1, G1, B1) are the reference RGB values and (R2, G2, B2) are the measured RGB values.

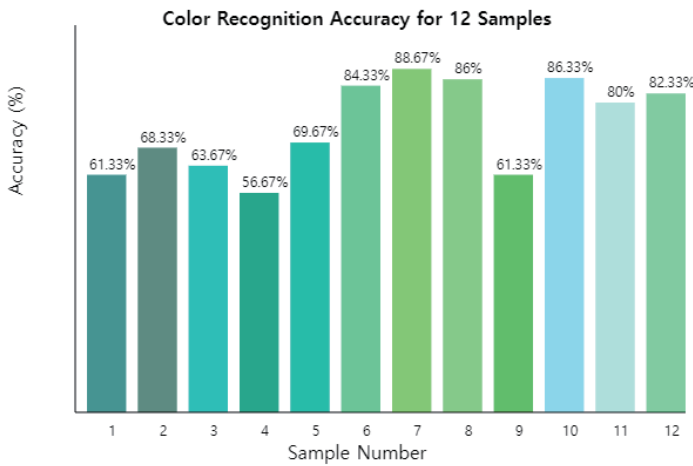


Figure 2. Color recognition performance for 12 green-series color samples.

3.2. Processing Speed and Luminance Calculation

On average, the system could process 4.96 objects per minute. The system also calculates luminance using:

$$\text{Luminance} = 0.2126 * R + 0.7152 * G + 0.0722 * B \quad (6)$$

$$\text{Brightness Level} = \text{map}(\text{Luminance}, 0, 255, 1, 10) \quad (7)$$

3.3. System Stability

The introduction of the integrating sphere with a curved baffle and titanium white coating significantly reduced the system's sensitivity to external lighting variations, maintaining consistent performance under diverse conditions..

4. Discussion

The results indicate the effectiveness of our approach in improving color recognition accuracy and stability. The integration of a curved baffle and titanium white coating in the integrating sphere design represents a significant advancement in color sensing technology.

5. Conclusions

This study presents a color classification system that enhances the performance of the color sensor by utilizing an optimized integrating sphere with a curved baffle and titanium white coating. The system demonstrates improved accuracy and stability in color recognition, addressing the limitations of conventional color detection systems in varying light conditions. Future work will focus on evaluating the system's performance with a wider range of objects and environmental conditions, as well as exploring potential applications in various industrial sectors.

Supplementary Materials: Not applicable.

Author Contributions: Conceptualization, J.Y.; methodology, J.Y.; software, J.Y. and D.K.; validation, J.Y., S.Y. and D.K.; formal analysis, J.Y.; investigation, J.Y.; resources, D.Y.; data curation, J.Y.; writing—original draft preparation, J.Y.; writing—review and editing, J.Y., S.Y., D.K. and D.Y.; visualization, J.Y.; supervision, D.Y.; project administration, J.Y.; modeling, J.Y. and S.Y. All authors have read and agreed to the published version of the manuscript.

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Bridging Multi-Imaging Modalities Using Deep Learning for Comprehensive Insights on Resting State Brain Activities

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Abstract: In the pursuit of understanding the complexities of the human brain, combining Electroencephalography (EEG) and functional Magnetic Resonance Imaging (fMRI) provides a powerful approach. This paper introduces a methodology to merge these two brain imaging techniques, aiming to leverage their complementary strengths. EEG captures the rapid dynamics of neural activity with high temporal resolution, while fMRI offers detailed localization of brain functions with superior spatial resolution. By integrating EEG and fMRI, we can overcome the limitations of each technique when used separately, resulting in a more comprehensive understanding of brain activity. We discuss advanced techniques for synchronizing and integrating EEG and fMRI data which are acquired simultaneously in resting state, highlighting the role of innovative computational methods and machine learning algorithms in enhancing data fusion. We have developed a Transformer-CNN model to generate fMRI data from EEG and have assessed the accuracy of the predicted fMRI data compared to the ground truth both quantitatively and qualitatively. Our study is still ongoing, but it demonstrates the potential of leveraging deep learning for enhancing multimodal brain imaging. We have also shown the feasibility and applicability of synthesizing EEG-to-fMRI in resting state, which could be valuable for neuroscientific research.

Keywords: Multimodal imaging, deep learning, EEG, fMRI

1. Introduction

Understanding the intricate workings of the human brain remains one of the most profound challenges in contemporary neuroscience. In this pursuit, the integration of Electroencephalography (EEG) and functional Magnetic Resonance Imaging (fMRI) has emerged as a pivotal approach.

EEG excels in capturing the rapid temporal dynamics of neural activity, offering millisecond-level resolution, while fMRI provides detailed spatial localization of brain functions with high anatomical specificity. By combining these two techniques, researchers aim to harness their complementary strengths and overcome their individual limitations, thereby achieving a more comprehensive understanding of brain activity. However, this integration faces technical challenges and cost constraints, limiting its widespread adoption. Foundational research has explored deep learning-based techniques for transforming EEG data into fMRI images. For instance, David Calhas investigated models using Auto-Encoders and GAN structures to generate fMRI images from EEG data [1]. Other studies employing attention-based deep learning models have compared generated fMRI images with actual scans, revealing similar patterns related to conditions like schizophrenia in specific brain regions [2].

Despite these advancements, existing deep learning models often fail to fully capture the neuroscientific correlations between EEG and fMRI. Previous research has established correlations between low-frequency brain waves, such as alpha and beta bands observed in EEG recordings from the occipital region, and the Resting State Network (RSN) identified via fMRI [3]. Building on this foundation, our study addresses an EEG-to-fMRI generation framework that specifically reflects these neuroscientific correlations. We focused on transforming resting state EEG data into time-frequency spectrograms after filtering for low-frequency brain waves, utilizing a Transformer-CNN model as our generative deep learning architecture.

2. Materials and Methods

2.1. Dataset

In this study we used a publicly available dataset called the NODDI dataset, which includes EEG-fMRI pairs collected simultaneously during resting state from a group of 16 patients. EEG recordings were gathered using a 64-channel MR-compatible electrode cap. The fMRI data comprised 300 volumes acquired with a repetition time (TR) of 2160 ms and an echo time (TE) of 30 ms, covering 30 slices with a voxel size of 3.3 x 3.3 x 4.0 mm.

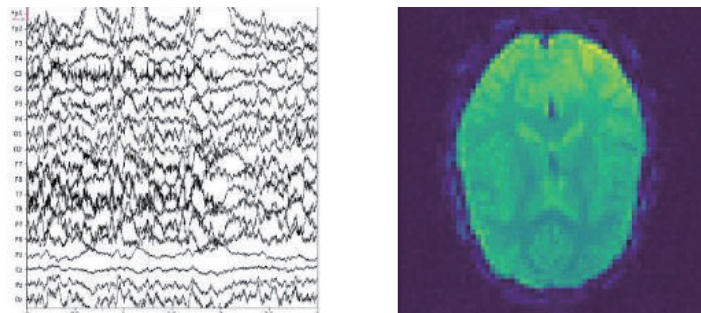


Figure 1. EEG and fMRI samples from the NODDI dataset.

2.2. Data Preprocessing

2.2.1. EEG

The aim of the preprocessing is to transform EEG data into spectrograms organized by channel and frequency bands, as outlined in the introduction. The preprocessing pipeline for EEG, illustrated in Figure 2, encompasses four key steps.

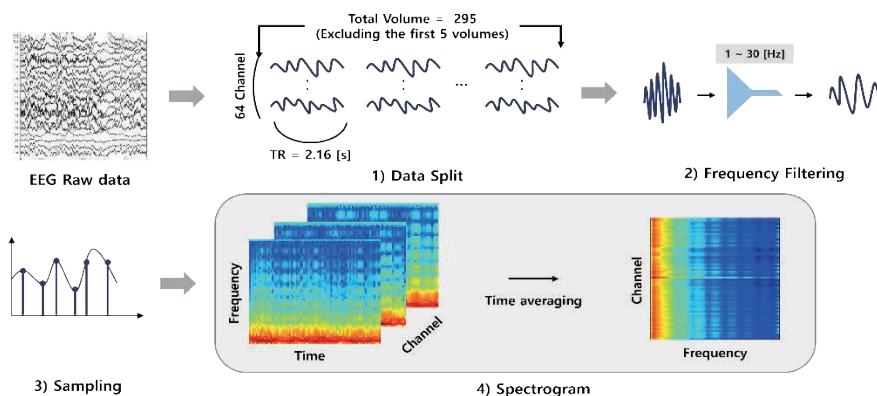


Figure 2. EEG Preprocessing pipeline.

Firstly, in the data cropping step, the time domain of EEG is segmented. This segmentation aligns EEG data with each fMRI volume, divided at intervals corresponding to a TR of 2.16 seconds. EEG data from the initial 5 volumes, as detailed in Section 2.1, are excluded from analysis.

Secondly, frequency filtering is employed to isolate EEG signals within the low-frequency range. A band-pass filter is applied to retain frequencies between 1 to 30 Hz, encompassing delta (1-4 Hz), theta (4-8 Hz), alpha (8-13 Hz), and beta (13-30 Hz) bands commonly utilized in brainwave analysis.

Next, sampling adjustments are made to modify the data acquisition rate. The initial EEG data, sampled at 5000 Hz, is downsampled to 1000 Hz. This reduction in sampling rate minimizes data volume while enhancing processing efficiency.

Finally, in the fourth step, Fourier transform is utilized to convert channel-specific brainwave data into a frequency-time representation, generating spectrograms structured as (channel x frequency x time). To prepare data for deep learning model training, a time averaging technique is applied, compressing the temporal dimension into a format of (channel x frequency). This preprocessing workflow enables the transformation of raw EEG signals into spectrograms that capture detailed channel-specific frequency dynamics, essential for subsequent neuroscientific analysis and model training.

2.2.2. fMRI

Spatial normalization is a crucial process that aligns brain images to a standardized space, facilitating consistent analysis across different subjects. This normalization aids in deep learning model training by ensuring that structural aspects of the brain are learned consistently across patients.

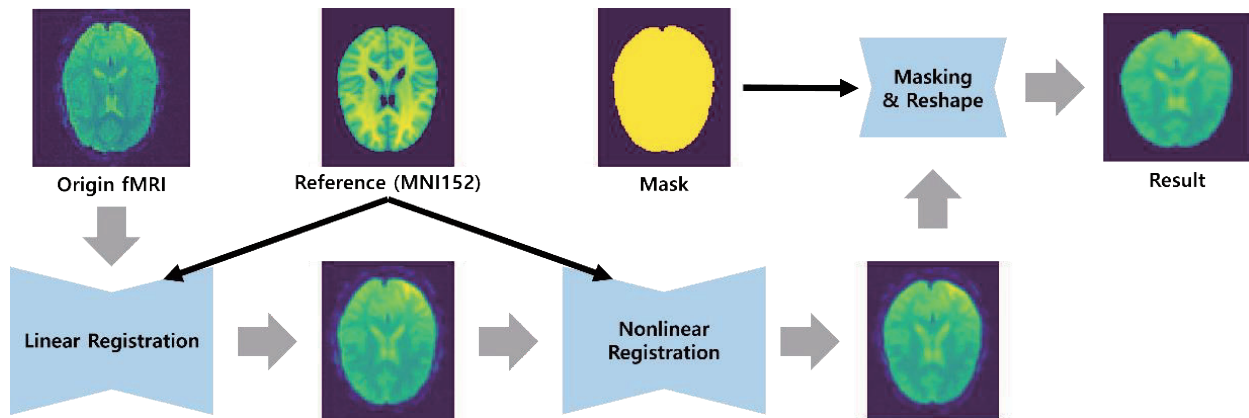


Figure 3. fMRI Preprocessing pipeline.

The fMRI preprocessing pipeline, summarized in Figure 2, comprises three main stages: linear registration, non-linear registration, and masking. The standard template used for spatial normalization in this study is the MNI152 template, which has dimensions of $91 \times 109 \times 91$ and a voxel size of $2 \times 2 \times 2$ mm.

In the first stage, linear registration is applied to align the fMRI data with the reference MNI152 template. This step adjusts for differences in structure, size, and spatial position between the fMRI data and the template. The Affine Transform algorithm is utilized for this linear registration process. Following linear registration, the second stage involves non-linear registration. This step addresses more complex differences in brain structure and shape that cannot be fully corrected by linear registration alone. The Symmetric Normalization algorithm is employed here to transform the fMRI data into the shape of the standard brain structure defined by the MNI152 template.

In the masking stage, skull stripping is performed to remove non-brain tissues from the fMRI data. Instead of using FSL's single-volume skull stripping method, which can be time-consuming, a method is employed that utilizes brain mask data derived from the reference MNI152 template. This approach quickly masks out areas outside the brain structure by transforming the brain mask data into the same space as the fMRI data.

After masking, the fMRI data is resized back to its original dimensions of $64 \times 64 \times 30$, ensuring compatibility with subsequent analyses and preserving the original spatial resolution necessary for accurate brain mapping and functional connectivity studies. This comprehensive preprocessing workflow prepares fMRI data for further analysis, ensuring it is standardized and optimized for subsequent deep learning model training and neuroscientific investigations.

2.3. Transformer-CNN model

2.3.1. Model structure

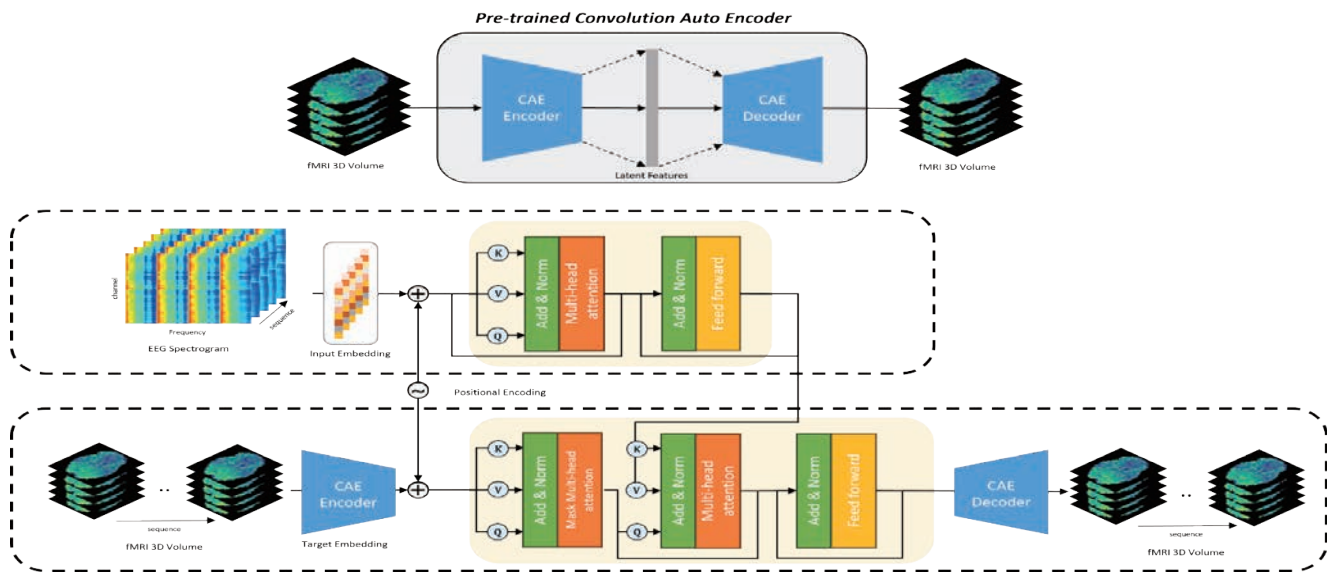


Figure 4. Transformer-CNN architecture.

2.3.2. Model evaluation methods

The dataset comprises EEG-fMRI pairs collected from a total of 16 patients, with each patient contributing 295 pairs of data. This results in a total of 4720 samples. The samples are split into training, validation, and testing sets in a ratio of 0.5:0.25:0.25. Specifically, 2360 samples are used for training, 1180 for validation, and 1180 for testing. During training, Mean Squared Error (MSE) was used as the loss function, and optimization was performed using the Adam optimizer with a learning rate set to 1×10^{-5} . The evaluation metrics used were Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index Measure (SSIM). The training process continued for 100 epochs.

3. Results

Figure 5 illustrates the changes in Loss, PSNR, and SSIM values at each epoch until the training is completed. The model is learning effectively as indicated by the decreasing loss, and increasing PSNR and SSIM values over epochs. The similar trends between the training and validation sets indicate that the model generalizes well and is not overfitting. The stable PSNR and SSIM values at the end suggest that the model is able to generate high-quality and structurally accurate FMRI images from EEG data.

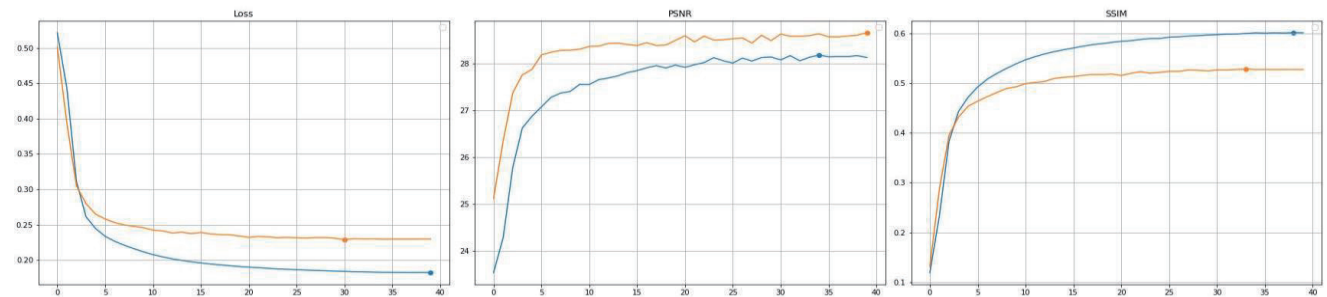


Figure 5. Learning-Validation Loss, PSNR, SSIM Graph.

Table 1 displays the metrics for the tested results. PSNR of 25.92 dB indicates a moderate level of similarity between the generated FMRI and the actual FMRI. The quality is not poor but it's not high enough to be considered excellent. SSIM of 0.56 reflects moderate structural similarity and indicates that while the generated FMRI shares some structural elements with the original FMRI there are noticeable discrepancies.

Table 1. The quantitative results of the proposed model

Loss	PSNR	SSIM
0.20899	25.92	0.56

To compare the transformed fMRI (prediction) with actual fMRI data, three types of visualizations were performed. This figure showcases visual comparisons between generated fMRI images and actual fMRI data. The overall shape and main features of the brain regions seem to be well-captured by the model, there may be slight blurring or smoothing in the predictions, which is common in generated images. The prediction show a decent amount of details, although some finer details may be less pronounced compared to the ground truth.

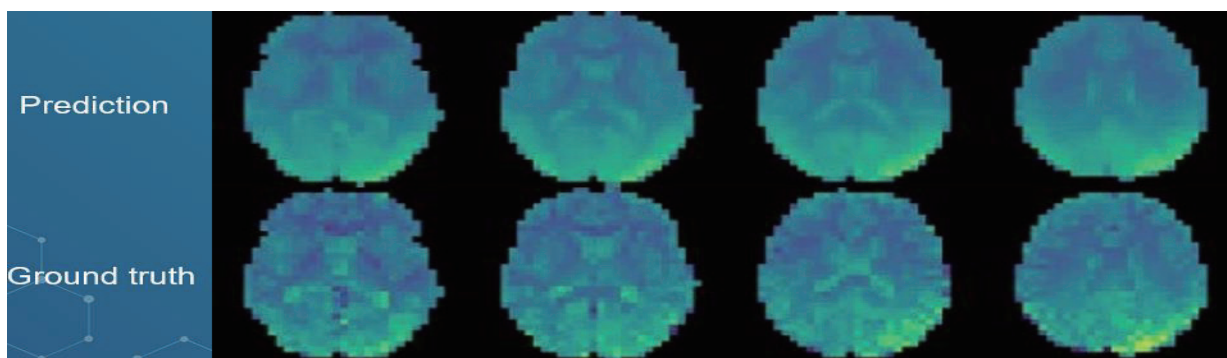


Figure 6. FMRI prediction and target comparison.

The second type of comparison focused on extracting the average BOLD signal between brain regions using brain parcellation with the Harvard-Oxford cortical and subcortical atlas. Figure 8 displays the outcomes of comparing the generated and actual BOLD signals. The predictions (blue line) closely follow the overall trend of the ground truth (orange line). The ground truth data shows several high peaks, which are not as prominent in the predictions. It seems that the model smooths out some of the variability in the ground truth data, resulting in less extreme peaks. This suggests that while the model captures the general trend, it may underestimate the intensity of certain events or fluctuations. Overall, the model effectively generates predictions that align with the general pattern of the ground truth data for the Frontal Pole region, but it tends to reduce the impact of extreme variations.

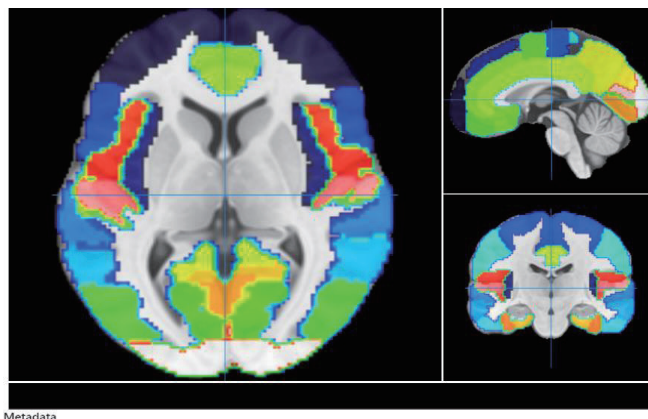


Figure 7. Harvard-Oxford cort maxprob thr25 2mm.

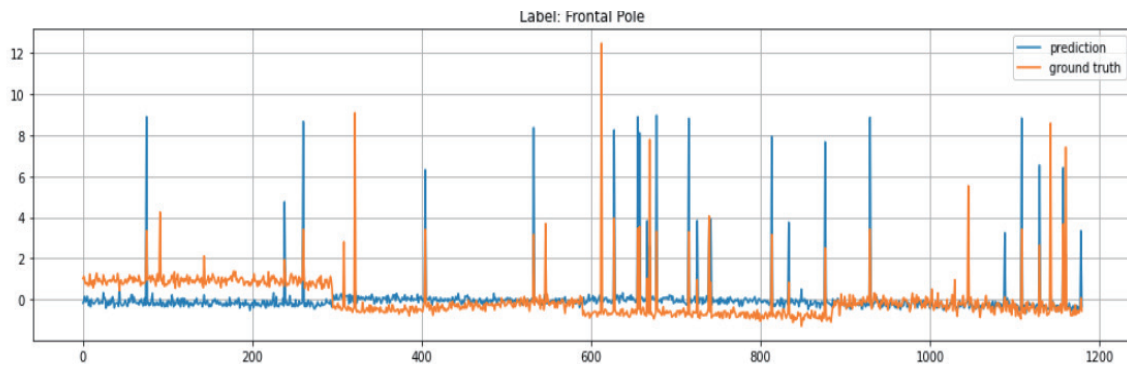


Figure 8. Bold Signals comparison.

The third type of comparison entailed visualizing the correlation matrix of extracted BOLD signals between brain regions to analyze their relationships. Figure 8 depicts the comparison between the predicted correlation matrix and the actual correlation matrix.

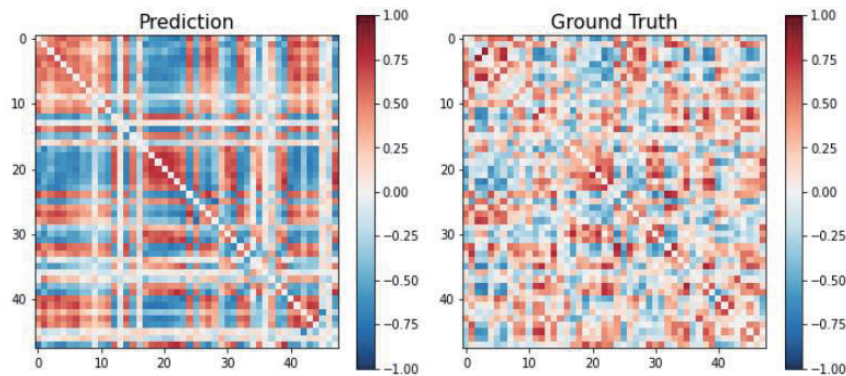


Figure 9. Correlation matrix comparison.

4. Discussion

The study proposed a framework for generating fMRI data from EEG in order to establish the neuroscientific relationship between these modalities. The process involved filtering EEG data into the low-frequency band and then transforming it into spectrograms. These spectrograms were further processed using a Transformer-CNN model for learning. The model achieved PSNR and SSIM values of 25.92 and 0.56 respectively. While these values were not excessively low, they still indicated a noticeable disparity between the generated fMRI and actual fMRI in qualitative assessments. This was particularly evident in the analysis of brain functional networks, where accuracy was limited in average BOLD signal comparisons across brain regions and correlation matrix visualizations.

Despite these challenges, the study demonstrates the feasibility of the EEG-to-fMRI generation framework. The performance of our Transformer-CNN model for generating fMRI data from EEG inputs can be significantly enhanced by integrating advanced training techniques, model architecture improvements, and robust data pre-processing. One approach for improvement involves applying denoising algorithms after prediction to clean up the fMRI images. Additionally, utilizing models such as SRGAN (Super-Resolution GAN) can enhance the resolution and quality of the generated fMRI images.

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A Preliminary Study on EEG Brain Signal Preprocessing for Extracting Event-Related Potentials

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Abstract: Electroencephalography (EEG) is a vital part of neuroscience research, providing insight into brain activity by non-invasive measurement of electrical potentials. The raw EEG data is frequently contaminated with artifacts from many diversified sources, such as eye movements, muscle movements and environmental noise. Efficient preprocessing is vital for an improved efficacy of a signal, along with its robustness. This paper presents a structured procedure for preprocessing an EEG signal for extraction of event-related brain potentials (ERPs) and for decomposing the signal into its frequency bands. The BrainVision system recorded the EEG data, and before analysis, we carried out preprocessing steps, which are: set channel types, use standard montages, resampling, referencing, filtering, Independent Component Analysis (ICA), event handling, and segmenting the frequency bands. We applied band-pass filters to isolate delta, theta, alpha, and beta bands, followed by Short-Time Fourier Transform (STFT), which provides spectrogram for each frequency band, and finally, our purpose was to compute ERP (Event-Related Potential) time-locked averages over defined channels using the processed data. The outcomes of the above procedure demonstrate the efficiency of our process in removing artifacts and enhancing the clarity of our signal by showing the distinct patterns in the different bands of interest as well as the ERP waveforms. This methodological approach underscores the importance of meticulous preprocessing in EEG analysis, paving the way for more accurate and interpretable results in cognitive and clinical research. By following the methodology in this paper, researchers can have more accurate and interpretable results, either for cognitive or clinical research. Incorporating advanced signal processing technology, this study proposes a powerful framework for the EEG data analysis, which will provide a thorough understanding and exploration of the dynamics of the brain.

Keywords: EEG, Non-invasive brain imaging, Event-Related Potentials, Independent Component analysis, Short-Time Fourier Transform

1. Introduction

Electroencephalography (EEG) and functional Magnetic Resonance Imaging (fMRI) has emerged as a pivotal approach. Electroencephalography (EEG) exploits the advantages of being non-invasive, offering a high temporal resolution, and having applications in clinical settings, research, and technology development. Thus, it is a useful tool for studying brain activity [1-3]. The electrodes placed on the scalp to read the electrical pulses generated by brain neurons firing create the EEG. The signals are then recorded and amplified so that researchers can explore the brain signals further. There are many ways that the raw EEG data can become contaminated, including by environmental noise, electrooculogram (EOG), and electromyogram (EMG) signals [4,5], where the most common is the movement of the eyes. In recent years, various scholars have pursued different paths to overcome artifacts. To expedite and enhance the preliminary stages of EEG data processing, the authors suggest a standardized early stage EEG processing pipeline known as PREP [6]. The three main characteristics are generated reports, multistage referencing, and automated processing. More than 600 EEG datasets have been processed using the PREP pipeline. However, it has certain restrictions, such as Bad channels are those that have a high noise level or poor correlation. Inadequate channel count can also result in imprecise channel interpolation. The amount of EEG data has expanded considerably with the development of high-density EEG and large-scale participant investigations. J.R. da Cruz et al. [7] suggest a novel automated pipeline (APP) for EEG data pre-processing and artifact rejection in order to overcome this. Two forms of EEG data—Event-Related Potential (ERP) data and Resting-State (RS) data—were used to test this pipeline. Compared to the other techniques, this pipeline

rejected fewer bad epochs and bad channels. Higher signal amplitudes were produced in the ERP study compared to the FASTER method, which was more in line with the outcomes of the experimentally supervised methodology. It is not recommended for datasets with fewer than 32 channels, and it is only suitable for testing on 64-channel datasets, among other constraints. IC classification is challenging since there are insufficiently precise measurements. MRI settings and severe conditions are not suggested for its use. Researchers used children's EEG signals in [8] because they had more artifacts and shorter recording periods than adult EEG signals, which are harder to manage. For this reason, the Maryland Analysis of Developmental EEG (MADE) pipeline was created in order to handle these difficulties. It is an automated preprocessing program made specifically for use with children's EEG data. MADE may be configured to work with a variety of EEG hardware devices and can adjust to variable noise levels and recording durations. The drawback of this pipeline is that it uses ICA rather than EOG channels for artifact rejection. It is challenging to identify trustworthy brain biomarkers in EEG data since the techniques are inconsistent and time-consuming. DISCOVER-EEG is a fully automated pipeline designed by Cristina et al. to preprocess, analyze, and visualize resting-state EEG data [9]. The goal of this pipeline is to expedite the process and reduce reliance on the techniques used by individual researchers. Two sizable publicly accessible datasets, including patients with psychiatric conditions and healthy participants, were used to evaluate the pipeline. Because of convenience sampling used in participant recruitment, its representation is limited.

Additionally, Venkata Phanikrishna et al. have investigated various ways for segmenting and preprocessing EEG data, which are essential for deep learning-based classification methods and automated machines [10]. They went over EEG signal processing methods for analyzing brain activity. In order to learn crucial information about a variety of neurophysiological processes, the main sub-band components delta, theta, alpha, beta, and gamma were extracted from EEG signals in this investigation. The HAPPE In Low Electrode Electroencephalography (HAPPILEE) pipeline was also created by K.L. Lopez, A.D. Monachino, S. Morales, and colleagues [11]. Its purpose is to preprocess lower-density EEG data, optimize it for different channel layouts, and make it appropriate for both resting-state and task-related EEG recordings. Testing of this pipeline has been done using both actual and synthetic EEG data. It can handle both task-related and resting state EEG recordings and is appropriate for any lower-density EEG setup.

Even with all of the experimenting in this sector, there are still a lot of gaps. We are therefore inspired to work on this subject. There are various reasons for working on the preprocessing and analysis of EEG signals for ERP and frequency band analysis. First, strong preprocessing methods are obviously required to guarantee the precision and consistency of EEG data, which is essential for cognitive research as well as clinical diagnosis. Second, there is a great deal of promise to improve the quality of EEG analysis by the incorporation of modern signal processing techniques like ICA and STFT.

Finally, we may advance our understanding of brain dynamics and pave the path for future discoveries in neuroscience and more successful clinical interventions by refining the preprocessing and analytic pipeline.

2. Materials and Methods

The explanation of the experiment's methodology will be included in this part. The study's overall preparation techniques are shown in Figure 1.

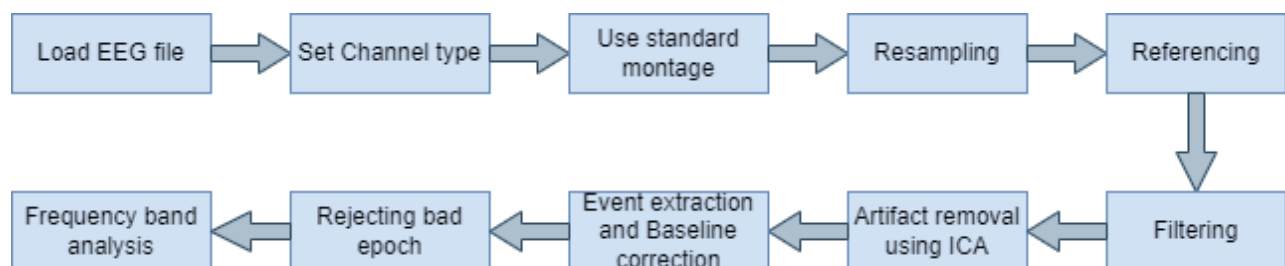


Figure 1. Overall workflow for preprocessing.

2.1. Data Acquisition

This experiment's dataset was acquired from Germany's Leibniz Institute for Neurobiology (LIN). The Brain Vision recorder system was utilized to capture the EEG data at a sampling frequency of 5000 Hz. Here, resting EEG data was loaded with the help of the MNE-Python module. There were 66 EEG channels in the dataset, with some reserved for electromyography (EMG) and electrooculography (EOG). An accurate 10-20 montage was used to map the sites of the electrodes.

2.2. Resampling and referencing

The data was resampled to 250 Hz in order to normalize it. While maintaining the necessary information, a lower sampling rate minimizes the amount of data, speeding up processing and requiring less computing power. Resampling correctly prevents aliasing, which can tamper with the signal and skew the analysis while preserving the integrity of the EEG signal. In order to lower common noise on all channels, an average reference was used [12]. Referencing has a big impact on how EEG signals are interpreted. It can achieve this by distributing the contributions from each electrode such that the data is more indicative of brain activity.

2.3. Filtering

High-frequency noise, low-frequency drifts, and other artifacts that mask the actual brain activity can be present in the raw EEG data [11]. For this reason, we used a band-pass filter [13] to filter out any signal components over 30 Hz, such as high-frequency noise and muscular distortions, and eliminate any signal components below 1 Hz, such as gradual drifts and direct current (DC) offset. The signal-to-noise ratio is increased by eliminating unneeded low- and high-frequency noise, which increases the dependability of the EEG data for subsequent preprocessing procedures like feature extraction, epoch, and artifact removal.

2.4. ICA(Independent Component Analysis)

Independent component analysis (ICA) is a BSS technique that has been extensively utilized for artifact removal and is predicated on the ideas of mutual linear independence across sources and non-Gaussianity [14]. In order to accomplish BSS, we used the FastICA algorithm in this experiment to measure convergence speed. A fixed point iteration strategy is the foundation of the FastICA, which finds the maximum of wT x's non-gaussianity [15]. This method was used to correct eye movements and blinks.

2.5. Baseline correction and rejection of bad epoch

Following ICA, events were taken out of the data and corrected for baselines. In order to ensure that the epochs are normalized and centered on a constant baseline level, baseline correction is an essential step in the preprocessing of EEG data [13]. This eliminates any gradual drifts or DC offset in the signal that can mask the actual brain responses. Next, depending on predetermined functions, epochs containing artifacts were disregarded.

3. Results and Discussion

More distinct frequency band features and clearer EEG traces are examples of how the preprocessing processes greatly enhanced the data quality. The band-pass filtering identified and filtered the appropriate frequency bands (beta, theta, alpha, and delta) after the ICA successfully eliminated artifacts related to eye movement. The data were filtered into the following frequency bands: alpha (8–13 Hz), beta (13–30 Hz), theta (4–8), and delta (1–4 Hz) [16,17]. In order to better visualize power changes, log-scaled spectrograms are shown. To visualize the frequency content of the signal in three dimensions, a three-dimensional plot of the delta band's short-time Fourier transform (STFT) spectrogram is made.

3.1. ERPs (Event-Related Potentials)

Following that, the ERPs of Fp1, Fp2, and F3—which are located in the frontal and frontopolar regions, respectively—were analyzed and their waveforms were clearly visible. Planning, decision-making, and goal-directed behavior are examples of higher-level executive processes that are mostly handled by the frontopolar cortex. F3,

on the other hand, is engaged in executive processes like planning, thinking, and problem-solving. The greater amplitude at the frontal pole electrode, as seen in Figure 2, indicates that the frontopolar region of the brain is responding to the stimulus more strongly than the frontal region.

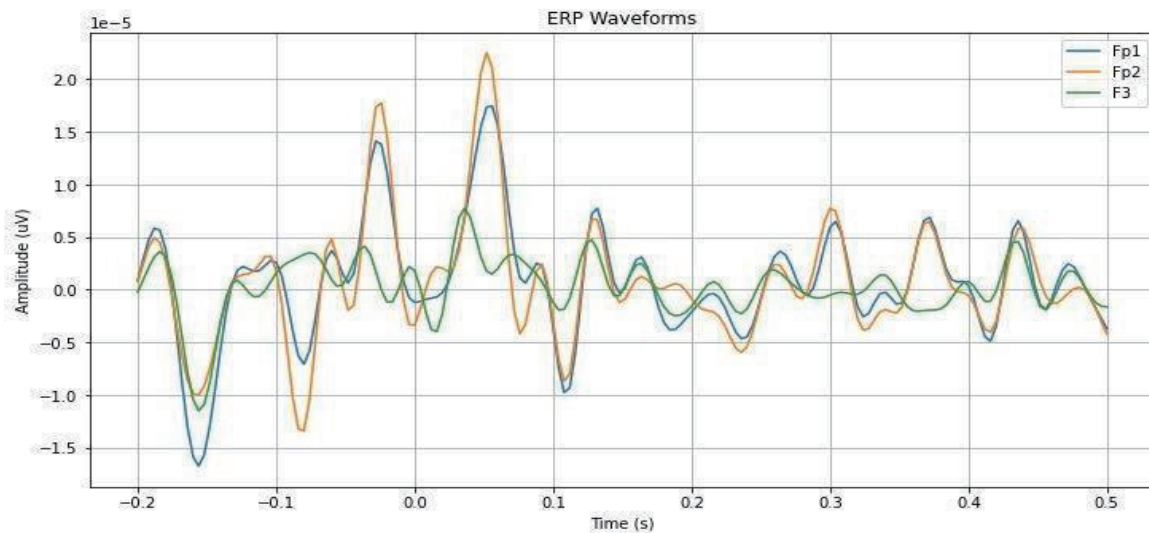


Figure 2. Average ERPs waveform for channel Fp1, Fp2, and F3.

Our approach shows that in order to extract significant characteristics from EEG data, it is crucial to combine meticulous preprocessing methods with sophisticated frequency domain analysis. The implementation of STFT allowed for a thorough analysis of frequency-specific activity, and the use of ICA was essential for the removal of artifacts. The resulting ERPs offer important new information on the dynamics of the brain that underlie cognitive functions. The spectrograms show the oscillatory activity of the brain by revealing unique patterns in various frequency bands.

4. Conclusion

This work offers a thorough preparation pipeline for EEG data, removing frequent artifacts and enhancing the data's analytical potential. The instructions give a thorough framework for EEG data preparation, including everything from channel type configuration to frequency band segmentation. Research on cognition and medicine can benefit greatly from the method's increased EEG analysis reliability. Subsequent investigations may examine the incorporation of machine learning methodologies to facilitate automated identification and categorization of artifacts.

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Is AI-based Hair Removal in Pet Skin Images Effective to Improve Skin Disease Detection?

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Abstract: Machine learning tools have been extensively exploited by dermatologists to determine the skin diseases in humans. However, less studies have been conducted in case of animals since they possess dense hairs in their skin. There are many researches on inpainting models to remove hair in the human skin images. We aim to determine the best model that can remove hairs in dermoscopic images of pet animals, specifically dogs and cats, and ultimately enhance the performance of skin disease detection. Three inpainting models, including BAT-Fill, EBAT, and DeepFillv2, were assessed to remove hairs from hairy raw skin images of pets. Those models were trained using human skin image datasets since paired data of hairy and hairless skin images are unavailable. The EBAT model exhibited the best qualitative performance in hair removal among those models. The inpainting models will be further examined to improve the accuracy for detecting skin diseases from pet skin images. It is obviously challenging due to the vulnerability of hair removal models to the heterogeneity of skin images over species while the available data of pet images are not sufficient to train them. We are pioneering to develop a robust model integrating hair removal and disease classification that can achieve superior performance over diverse species of animals.

Keywords: animal skin disease detection, skin image hair removal, deep learning, image inpainting

1. Introduction

It is crucial to detect the skin disease accurately in veterinary dermatology for effective treatment. Dermoscopic images enhance the visualization of the skin's surface and have been widely used to diagnose various dermatological conditions in humans. Similarly, they possess a significant potential in veterinary. The challenging part of diagnosis with the animal skin is the presence of thick and dense hair in the image causing difficulty in accurate analysis. Deep learning tools for image processing and inpainting have helped to reconstruct images by removing hair in dermoscopic images, making the classification of diseases easier. This study describes a new approach to classify the animal skin diseases by examining the unprocessed dermoscopic images and processed images from different inpainting models. The comparison of the accuracy of the disease classification model on hairy and hairless images determines the effect of hair removal in dermoscopic images. The 30 combination of inpainting and effective classification tool could considerably enhance the accuracy and productivity in veterinary dermatology.

2. Materials and Methods

2.1. Image inpainting models for hair removal

The general framework of hair removal using image inpainting is given in the following figure. The image inpainting models, such as EBAT, BAT-Fill, DeepFill, Shift-Net, FMM, can be employed to remove hairs from skin image. The brief introduction of the inpainting models are as follows. See Figure 1 for the brief architecture of each model.



Figure 1. General Framework of inpainting models.

2.1.1. BAT-Fill

This inpainting model has diverse structure generator and texture generator [1]. Diverse structure generator utilizes transformers and texture generator utilizes convolutional neural networks (CNN) to produce high quality realistic images. The bidirectional and autoregressive transformers (BAT)s predict the possible structures for the hair in dermoscopic images and CNN refines the predictions and add textures for the generation of the hairless images.

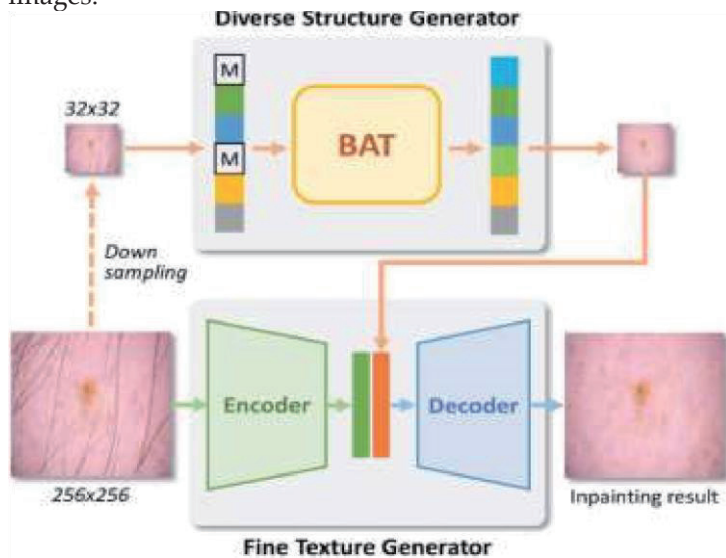


Figure 2. EBAT: This inpainting model has multi-scale feature extractor and fine texture generator [2]. In multi-scale feature extractor, it has utilized the BATs similar to BAT-Fill and CNN to generate multi-scale feature maps that predict the missing regions. Then, the fine texture generator rebuilds the missing part’s fine texture by linking up the low-resolution feature maps from BAT and CNN through up-sampling. This model was trained with 3,000 manually selected images from ISIC-2020 dataset. 100 was used for validation and 150 was used for evaluation.

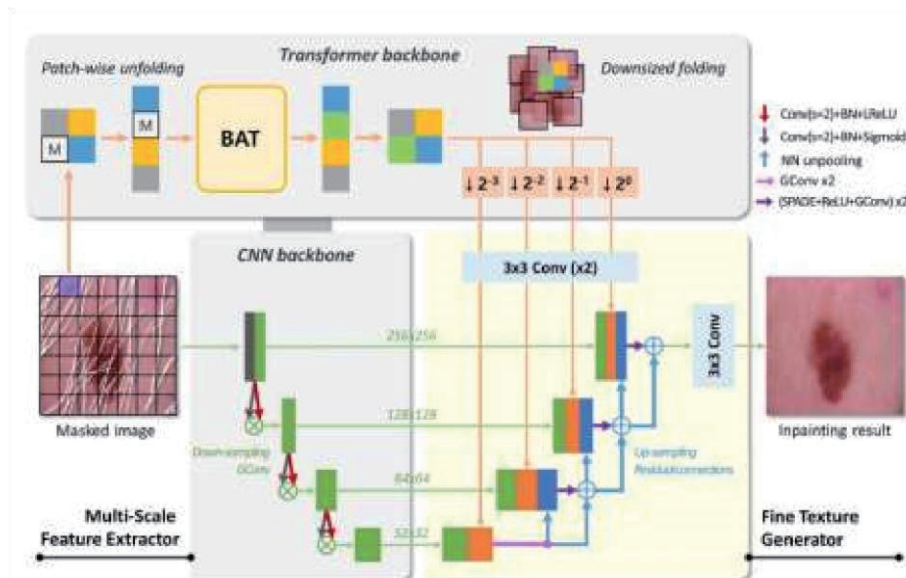


Figure 3. DeepFillv2: This inpainting model has a generative image inpainting structure that proposed gated convolution to reconstruct the images with free form masks [3]. SN-PatchGAN is introduced in the model because free form mask does not appear in a specific place in the image.

100 hairy animal skins were tested to predict the hairless images in three different models including, bidirectional autoregressive transformers (BAT)-Fill, enhanced bidirectional autoregressive transformers (EBAT) and DeepFillv2. These models were trained to remove hair in human skin images.

2.2. Overall framework

Furthermore, the classification of diseases will be determined on the basis of the predicted hairless images from those models. The overview of skin disease detection is shown as follows.

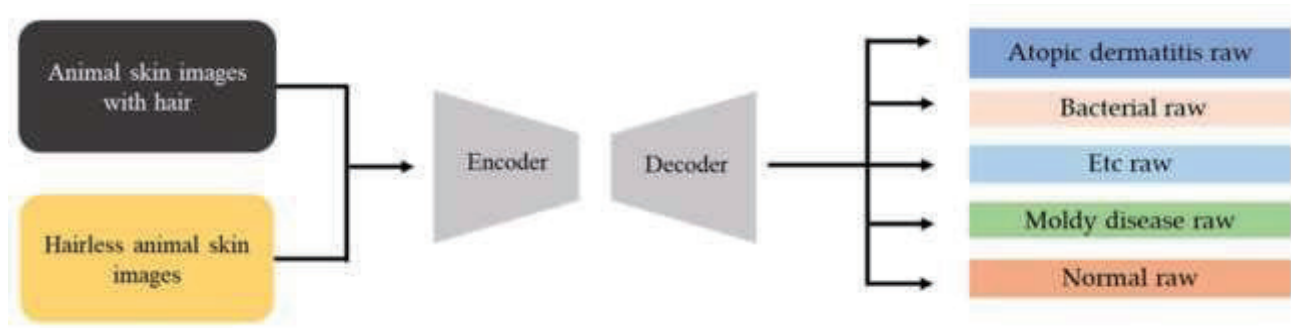


Figure 4. General framework of classification models.

We have animal skin images that are labelled according to the diseases. The dermoscopic images are classified into following five groups: Normal, Atopic dermatitis, Bacterial, Moldy, and others.

Studies show that the human diseases have link with pets. Atopic dermatitis is common skin diseases in pets like dogs and cats with similarity in the distribution of lesions in humans [4,5]. Contact with dogs possess risk in infection by bacteria, fungi and viruses [6,7]. We are exploring various classification models to examine the data. Classification performance of CNN models such as ResNet50 [8], EfficientNet_B4 [9], DenseNet201 [10] and ConvNeXt_L [11] have been studied on acne like skin diseases [12]. Study on the classification to discriminate 3 dog skin diseases (bacterial dermatosis, fungal infection, and hypersensitive allergy) from non-diseased skin images was performed by training data on ResNet [8], Dense Net [10], Inception Net [13] and MobileNet [7,14].

We will be implementing these models to classify the disease in animal skin images and compare the results. We aim to train the classification models with the available data and determine that the models have higher accuracy in predicting the diseases correctly in the inpainted image than in the unprocessed image.

3. Results

The following figure shows the qualitative comparison of different inpainting models for hair removal on the simulated hairy images which were generated from ISIC 2020 datasets.

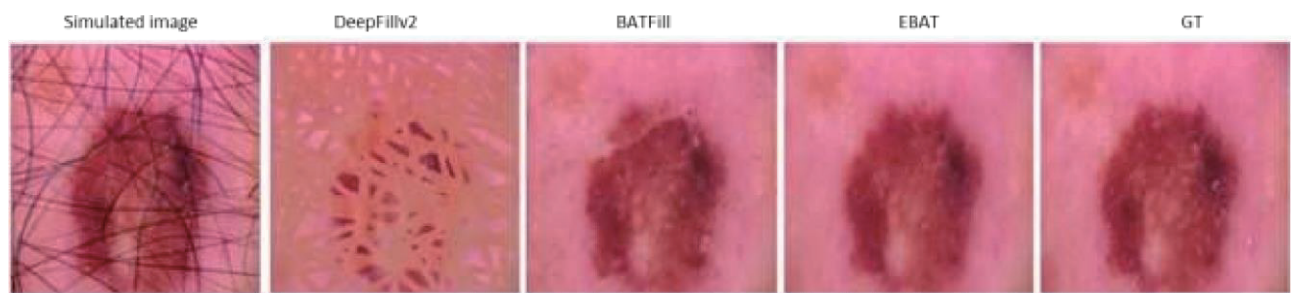


Figure 5. Qualitative comparison of different inpainting models for removing hairs over the simulated hairy images from ISIC 2020.

We have tested three different inpainting models to remove hair from the animal skin images which are trained for removing hairs in human skins images. Among the models we tested, EBAT model exhibited the best qualitative performance of removing hairs through visual inspection.

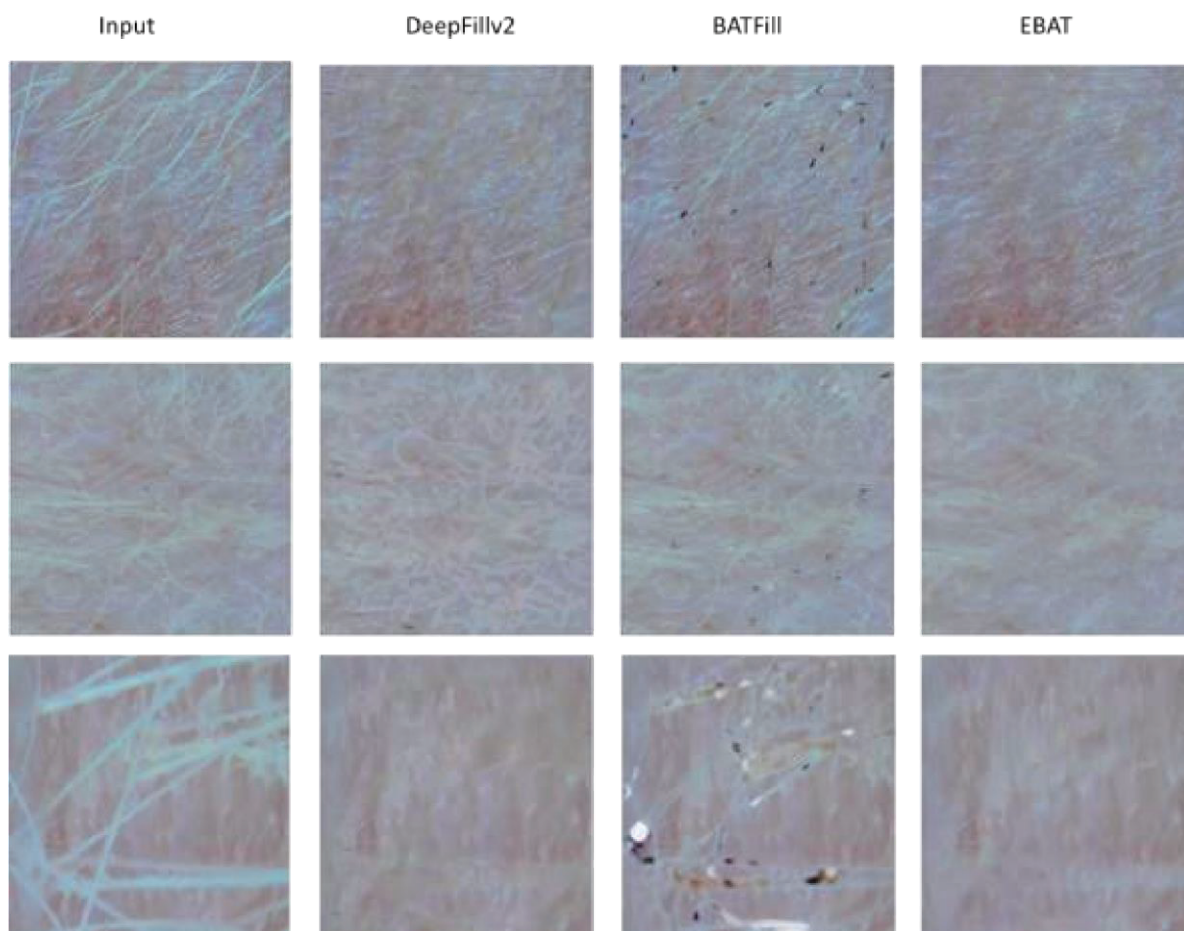


Figure 6. Qualitative comparison of different inpainting models for removing hairs on animal skin images. The models are trained for removing hairs over the simulated hairy images from ISIC 2020.

Even though the EBAT model had greater inpainting performance, there is still a place for its improvement. The main challenges of these inpainting models were the differences in skin types, hair color and thickness when tested on animal skin. We are researching on improving the model on these aspects. Next is the classification of image on basis of prediction from deep learning classification models. We expect that the accuracy of the classification models to predict the diseases is directly proportional to the percentage of the hairs in dermoscopic images.

4. Conclusions

Although wide researches have already been conducted in human skin for the identification and classification of various dermatological conditions, there are less study performed in animal skins. We conduct this study to show the potential of deep learning tools in veterinary dermatology.

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Session 5

**Medical & Health Studies
for Co-Prosperity**

Discovery and Efficacy of Filaggrin and TNF- α Modulating *V. amygdalina* Leaf-1 derived Biomaterials (AMXs) on Inflammatory Skin Diseases

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Abstract: Environmental inflammatory skin diseases, such as atopic dermatitis (AD) and contact dermatitis (CD) are 12 common skin disorders in both industrialized and developing countries. They are characterized by a defect of 13 the skin barrier and increased inflammatory response. Worldwide, the prevalence of environmental and 14 occupational dermatitis has increased exponentially during the COVID-19 pandemic due to the elevated 15 utilization of disinfectants and personal protective equipment (PPE). Steroids have long been used as the first 16 line treatment for dermatitis; but considering their side effects and contraindications, there is a need of effective 17 treatments with better safety profile. This mini-review highlights the skin health benefits of African plant *V. 18 amygdalina* leaf extracts (AMXs). We conducted experimental studies using mouse models of allergic contact 19 dermatitis (ACD), which showed that its aqueous (AMX1) and ethanolic (AMX2) leaf extracts were as effective 20 as topical steroid preparation in preventing ACD and relieving the number of scratching counts, skin erosion 21 and excoriation. Another study (immuno-fluorescence assay) showed that AMX and AMX-contained *Vernodalin* 22 both have significantly increased the production of filaggrin (FLG) in mouse skin and reduced plasma TNF-alpha 23 (vs. steroid). In our clinical investigation among Congolese patients with moderate AD and CD (N=25), AMX1 24 and AMX2 were as effective as steroid preparation; but relatively more effective in relieving pruritus and 25 wounded skin. Findings from this research suggest that AMXs improve skin barrier, with good efficacy and 26 safety profiles, and may serve as effective therapeutic agents for inflammatory skin diseases.

Keywords: Atopic dermatitis; Contact dermatitis; Eczema area severity index (EASI); *Vernonia amygdalina*

1. Introduction

Inflammatory skin diseases caused by exposure to occupational and environmental factors, such as atopic 31 dermatitis (AD) and contact dermatitis (CD), are common diseases in almost all countries. They are 32 characterized by a defect in the skin barrier and an increased inflammatory response [1, 2]. Their prevalence has 33 increased over the last few decades due to rapid urbanization, increased use of disinfectants and personal 34 protective equipment (PPE), especially during the COVID-19 pandemic [2].

Steroid-based drugs have long been the first line drugs or inflammatory skin diseases; however, given their 36 multiple side-effects and contraindications, there is a need to find new, safer and more effective treatments. This 37 report presents epidemiological profiles of AD and CD, and the main findings on the effectiveness of AMXs in 38 animal model of skin allergy as well as AD and CD patients.

2. Materials and Methods

2.1. Study desing

A brief review of the literature was conducted which included our publications related to the epidemiology of

environmental and occupational dermatitis. Then, the main findings of experimental and clinical studies carried out in Japan and D.R. Congo by our research team are presented.

2.2. Assessment of disease severity and Treatments

Animal studies were conducted using a preventive and a curative protocols; AD was induced in NC/Nga mice using 15 ml of 1% trinitrochlorobenzene (TNCB). The severity of skin lesions was evaluated macroscopically using a scoring scale described previously: 0, no symptom; 1, mild; 2, moderate; 3, severe) [3, 4].

The clinical investigation consisted in the treatment of atopic dermatitis (AD), allergic contact dermatitis (ACD) and irritant contact dermatitis (ICD) with the use of *V. amygdalina*-based AMXs and Beni-CD, in comparison with steroid drugs. For clinical investigation, treatment efficacy was assessed using the eczema area and severity index (EASI) scoring tool, estimating the severity score of skin lesions (erythematous macules, scaling/xerosis, squamous lesion, erosion, excoriation or scratching lesion). The EASI assessment integrates body surface and the intensity of lesional skin into a composite score as described previously [1, 5]. The effect of AMX on FLG production was assessed by immunopathological assay (immunofluorescence assay) in atopic mice skin samples. In animal experiments, the steroid ointment (0.1% hydrocortisone) was used as positive control treatment; the concentration of aqueous (AMX1) and alcoholic (AMX2) extracts of *V. amygdalina* was 7mg/mL. Regarding the clinical investigation, we used dexamethasone (steroid) as positive control and vaseline as negative control.

2.3. Data Analysis

For each study, data analysis was performed with the use of Stata statistical software version 15. Continuous data were expressed as means with the corresponding standard deviation; group comparisons were carried out using one-way analysis of variance (ANOVA). The statistical significance level was set at $p < 0.05$.

3. Results

3.1. Epidemiological profile of Atopic dermatitis and Contact dermatitis

It is well-established that AD is a disease characterized by a dysfunction of the skin barrier. Exposure to allergens (pollen and others) is a trigger for the disease. It is one of the most prevalent skin diseases worldwide, with approximately 204 million cases; 15-20% of children and 1-3% of the adult population are affected. Contact dermatitis (eczema) is an inflammatory skin condition generally caused by environmental and workplace factors, such as chemicals (paraphenylenediamine, detergents, drugs...), physical and mechanical agents (friction, pressure, thermal irritation, ultraviolet rays, etc.) and metals (nickel and others), inducing either a toxic effect on the skin or an allergic reaction. The severity of the disease depends on the quantity or concentration of the toxic product or agent, and the duration and frequency of exposure. Occupational CD is considered to be the most prevalent occupationally acquired illness, accounting for 70-90% of all occupational diseases [1, 2].

3.2. Mechanisms of Action of AMXs

FLG is known as the main protein that contributes to skin barrier formation, and drugs that can enhance FLG production would be useful in the management of inflammatory skin diseases that are characterized by a defective skin barrier. AMXs induce (1) an increase in FLG production via up regulation of pro FLG-m RNA expression and (2) a reduction of the production of a number of inflammatory markers (TH-1, Th-2 cytokines), particularly TNF-alpha as shown in Figure 1; thus, they have a great potential to alleviate inflammatory skin diseases [1].

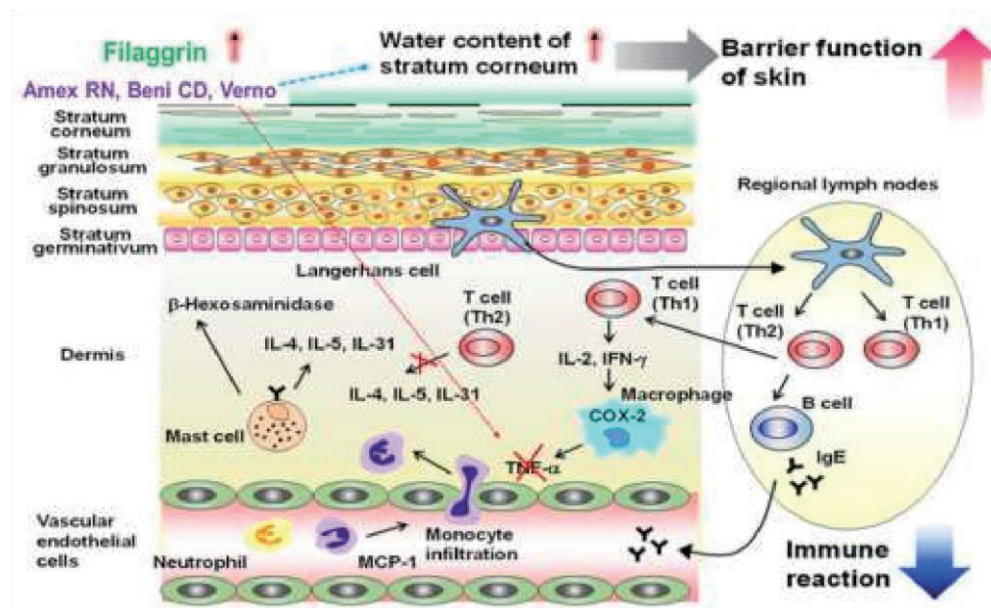


Figure 1. Anti-inflammatory mechanism of AMXs and their active molecule vernodalin [1].

V. amygdalina extracts have an anti-inflammatory effect; this is due to their inhibitory effect on a number of Th-1 and Th-2 inflammatory mediators such as TNF-alpha, interleukins 4 and 5 (IL-4, IL-5), as well as their modulatory effect on FLG production.

3.3. Experimental Efficacy of Topical application of AMXs in Mouse Models of Contact Allergy

In the preventive protocol of the animal study, pre-treatment with both AMX1 and AMX2 significantly prevented the increase in ear thickness ($p < 0.05$) and the development of AD-like disease skin lesions as compared with buffer in normal control mice throughout the experiment ($p < 0.001$). Similar result was observed for steroid-pre-treated mice. Furthermore, the curative protocol of the animal study showed that, compared to vehicle in normal control mice, treatment of allergic mice with AMX1, AMX2 and steroid markedly reduced the number of scratching counts and the severity of skin lesions, with AMX2 demonstrating a rapid alleviation of erosion and excoriation within the second week of treatment ($p < 0.01$) [1, 4].

3.4. Clinical Efficacy and Safety of Topical application of AMXs in AD and CD Patients

In this study, 25 pediatric patients with moderate AD or CD were divided into 4 groups of 6 to 7 each. Disease severity score was expressed as percent change from day1. AMXs and steroid treatments significantly reduced total itch and EASI scores throughout the treatment period (vs. Vaseline) (Figure 2) [1, 5].

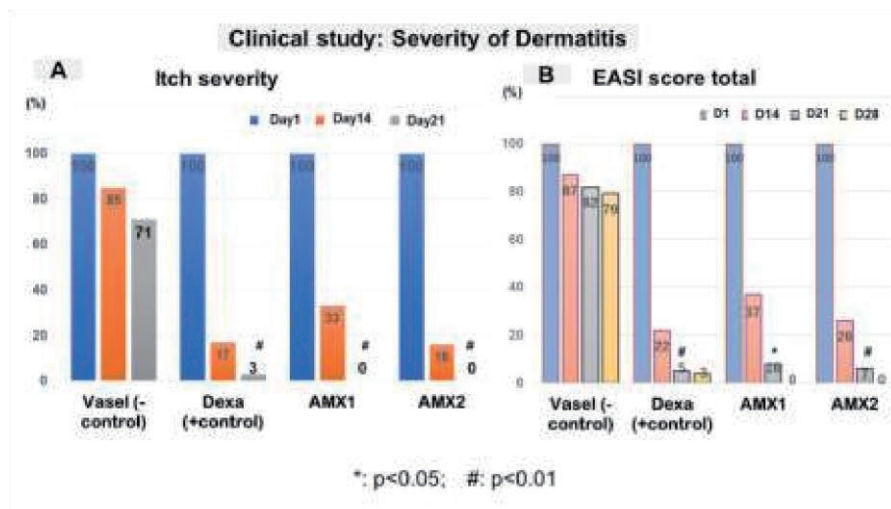


Figure 2. Percent change of the severity score for itch and eczema area severity index (EASI) according to treatment group. The figure shows suppression of itch in AMX-treated patients at week 3 of treatment. Additionally, marked improvement of skin status was observed in AMXs and steroid groups from the second week of treatment.

4. Discussion

Topical steroids are most widely used drugs for AD management; however, they are accompanied by poor adherence due fear of their unfavorable effects on skin barrier and side effects such as skin atrophy, hypopigmentation, telangiectasis, etc. Nonsteroidal therapies are thought to be good alternative treatments. For example, the inhibitors of calcineurin and immunosuppressors have been introduced particularly for AD [6, 7]. Almost a decade ago, we initiated a research project that used edible leaf extracts of *V. amygdalina*, an African plant used as remedy for chronic cough, diabetes and a number of cancers. In general, topical AMXs were as 111 effective as steroid drugs in alleviating erythematous and squamous lesions, whereas they had a relatively better effect on itch and wounded skin. Additionally, no side effect was observed in patients treated with AMX.

5. Conclusions

Findings from this research suggest that AMXs improve skin barrier, with good efficacy and safety profiles, and 116 may serve as effective therapeutic agents for inflammatory skin diseases.

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God's involvement revealed through modern medicine

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Abstract: It is difficult to feel God's involvement through modern medicine, although it is relatively easy to feel it through spiritual healing. I report on a case in which I felt God's involvement through modern medicine. The case was a 10-year-old girl who developed bilateral pneumonia three months after undergoing an unrelated bone marrow transplantation for relapsed acute lymphoblastic leukemia (ALL). Even with antibiotics, respiratory failure progressed rapidly, requiring mechanical ventilation 4 days after onset and extracorporeal membrane oxygenation (ECMO) 9 days later. The ECMO was continued for one month, but it would be difficult to continue any longer. Attending physician (AP) prayed to God and was taught that a lung transplantation (LT) was only a curative treatment. AP consulted with a pulmonary surgeon at another hospital about LT, and it was finally determined that LT was possible due to the selection of blood type-matched donors and proof that ALL is in remission. She was transferred by helicopter to another hospital with ECMO attached and received LT of one lung each from her parents successfully. She has been disease-free for 6 years after LT. It is considered that God was involved because LT was successful after overcoming various problems through the prayer of AP.

Keywords: God's involvement, modern medicine, acute lymphoblastic leukemia, lung transplantation, prayer

1. Introduction

It is difficult to feel God's involvement through modern medicine, although it is relatively easy to feel it through spiritual healing. I experienced a case in which a patient was able to save the life of a patient who was able to solve various difficult problems and perform bilateral lung transplantation (LT) for serious pulmonary complications after unrelated bone marrow transplantation (BMT) for recurrent acute lymphoblastic leukemia (ALL). At the same time, the attending physician (AP) was a believer in the Family Federation for World Peace, and the treatment method was taught while praying to God, and various problems were solved. I examined the possibility that God is involved in modern medicine, which is not a spiritual treatment.

2. Case presentation

The case was a 10-year-old girl. At the age of five years, she was diagnosed with B progenitor cell ALL. She got the first complete remission by multiagent chemotherapy. At the age of seven years, she completed chemotherapy while maintaining remission. At the age of nine years, she was diagnosed with the bone marrow recurrence of ALL. She got the second complete remission by multiagent chemotherapy. At the age of 10 years, she underwent allogeneic BMT from an HLA matched unrelated donor. She got engraftment and developed non-serious complications such as graft-versus-host disease and viral infection.

Three months after BMT, she developed bilateral pneumonia (Figures 1(a), 1(b)). Even with antibiotics, respiratory failure progressed rapidly, requiring mechanical ventilation 4 days after onset (Figure 1(c)) and extracorporeal membrane oxygenation (ECMO) 9 days later. The ECMO was continued for one month, but it would be difficult to continue any longer.

3. Results

3.1. Lung transplantation

Since lung damage was considered irreversible and it was difficult to continue further ECMO, bilateral lung LT was investigated. The feasibility of LT was consulted by a pulmonary surgeon at another institution. The patient had no complications in organs other than the lungs. In carrying out LT, it is necessary that the probability of

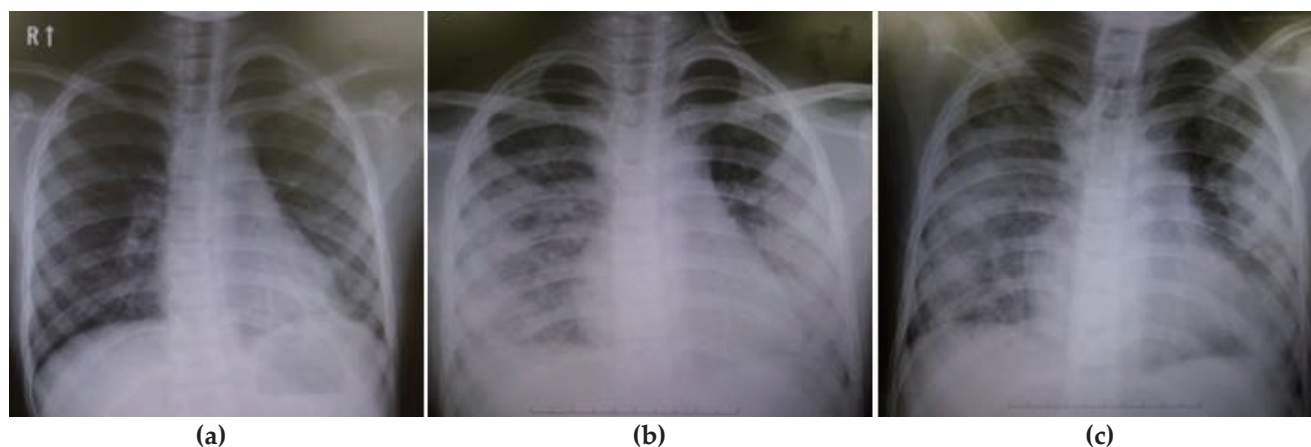


Figure 1. Chest X ray findings: (a) At the time of admission; (b) Two days after admission; (c) Four days after admission. Endotracheal intubation was performed.

recurrence of malignant tumor is not more than 20-30% after treatment of a malignant tumor. In general, it is carried out after a recurrence-free period of 2-3 years. In this case, it was approved to perform LT after presenting information to the ethical committee of the institution that the minimal residual disease of ALL was not detected in her bone marrow 91 days after BMT by next generation sequencing. Since infection was thought to be the cause of the lung damage, bilateral LT from two donors was considered. To become a LT donor, the donor had no underlying diseases, no history of smoking, and the patient's blood type matched, which the patient's parents met. However, the patient's parents had already divorced and his father had remarried. Therefore, I explained the situation to father's remarried partner and obtained her consent of that father becomes a LT donor. It was finally determined that LT was possible due to the selection of blood type-matched donors and proof that ALL is in remission. She was transferred by helicopter to another hospital with ECMO attached (Figure 2). The Self-Defense Forces' disaster prevention helicopter was used as a means of transporting patient to other institution. In order to use it, the director of the hospital requested a helicopter from the prefectural governor and obtained approval. She received LT of one lung each from her parents successfully. She has been disease-free for 6 years after LT.

3.2. God's involvement

The AP was a believer in the Family Federation for World Peace and Unification and prayed every day to save the life of the patient. Through his prayers, God taught him that a LT was only a curative treatment for the patient. The day before the AP consulted the transplant surgeon, the AP fell down the stairs and suffered bruises all over his body, and was taken to the hospital by ambulance. AP had to recuperate at home for three days, but he consulted with a transplant surgeon at home, despite bruises all over his body. In addition, the day the AP sent the patient by helicopter to another institution was the last day that the AP had worked at the hospital for 13 years. In order for God to be involved in things, the conditions of the central man are necessary. However, the prayers of the AP and the accumulation of 13 years of diligence in the hospital were not enough to meet the conditions. Therefore, it is presumed that AP had to be bruised all over his body and become a sacrifice.

4. Discussion

Childhood ALL studies have shown improved 5-year overall survival (OS) rates exceeding 90% [1]. Treatment of ALL comprises three phases: remission induction, consolidation (or intensification), and maintenance (or continuation), and lasts for 2-2.5 years. Allogeneic HCT has been used for patients at very high risk and relapsed ALL. Despite recent medical advances in the field of HCT, progressive and irreversible pulmonary complications after HCT, such as bronchiolitis obliterans syndrome and pulmonary fibrosis, remain significant and leading causes of death [2]. These lung diseases involve late-onset noninfectious pulmonary complications that may affect up to 26% of HCT recipients [3]. These lung diseases involve late-onset noninfectious pulmonary diseases is poor, with a survival rate of only 13% at 5 years postdiagnosis [2]. At present, there is no established



Figure 3. Patient transfer by disaster prevention helicopter: (a) Immobilization of the patient in the helicopter; (b) Entrance to the Disaster Prevention Helicopter; (c) Transferring ECMO-fitted patients into a helicopter; (d) ECMO in a helicopter.

standard therapy for pulmonary complications after HCT, although sporadic case reports and case series regarding the use of LT to treat these patients have been published [4]. However, patients undergoing HCT for hematologic diseases are generally considered high-risk candidates for LT, given the requirement for additional immunosuppression after LT and the presumably abnormal baseline immunologic capacity of these patients. Therefore, few LT procedures are performed in such patients. In Japan, the characteristics and outcomes of LT in patients exhibiting pulmonary complications of HCT were reported [5]. The median patient age at the time of LT was 24.5 years (range, 8-57 years). Diagnoses before HCT included hematologic malignancies in 55 (88%) and nonmalignant disorders in 7 (12%) patients. The median interval between HCT and the advent of pulmonary complications was 11 months, and the median interval between HCT and lung transplantation was 54 months (range, 9-180 months). Before LT, 61 (98%) of 62 patients depended on oxygen inhalation therapy. Thirteen (21%) patients required mechanical ventilation (duration, 2 weeks to 3 months), and 5 required noninvasive positive

pressure ventilation. The overall 1-year, 3-year, and 5-year survival rates were 85.5%, 75.7%, and 64.2%, respectively. In this patient, bilateral LT was performed for irreversible pulmonary complications. Despite the difficulties of selecting donors, proving ALL remission, and airborne transport with ECMO, miraculously everything went smoothly and the LT was a success.

This patient's LT was a success that solved a number of problems, but was it just a stroke of luck? The patient's AP was a member of the Family Federation for World Peace and Unification and prayed daily about the patient's healing and how to treat it. Through his prayers, God taught him that a LT was an effective treatment to solve this irreversible lung disorder. In order for something to be restored to a position or state which it has lost, certain conditions must be met [6]. To meet these conditions is to indemnify the loss of the original, and thus, to restore through indemnity. The day before the AP consulted the transplant surgeon, the AP fell down the stairs and suffered bruises all over his body, and was taken to the hospital by ambulance. In addition, the day the AP sent the patient by helicopter to another institution was the last day that the AP had worked at the hospital for 13 years. In order for God to be involved in things, the conditions of the central man are necessary. However, the prayers of the AP and the accumulation of 13 years of diligence in the hospital were not enough to meet the conditions. Therefore, it is presumed that AP had to be bruised all over his body and become a sacrifice.

5. Conclusions

It is considered that God was involved because LT was successful after overcoming various problems through the prayer of AP. Since God is involved even through modern medicine, it is recommended that the AP always pray for the patient's healing and cure, and establish conditions in which God can be involved.

Data Availability Statement: Not applicable

Conflicts of Interest: The author declares no conflict of interest.

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A Comprehensive Review of the Interlink between Mental Health and Spiritual Healing

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Abstract: This research looks at the complex relationship between mental health and spiritual healing, attempting to understand the mechanisms by which spiritual practices affect psychological well-being. While most mental health interventions rely on psychological and pharmacological techniques, the introduction of spiritual components into therapeutic paradigms has attracted attention for its potential to supplement and improve established treatments. This study, which draws on interdisciplinary research from psychology, neuroscience, anthropology, and spirituality, synthesizes existing information on how spiritual practices such as mindfulness, meditation, prayer, and ceremonial ceremonies affect mental health outcomes. It investigates the psychological processes that underpin spiritual experiences, such as stress response modulation, improved emotional control, and resilience development. Furthermore, this research also investigates the function of spirituality in dealing with adversity, trauma, and existential discomfort, emphasizing its importance in supporting meaning-making and existential well-being. This paper provides insights into the integration of spiritual interventions within mental health care settings by conducting a thorough analysis of empirical studies and theoretical frameworks. It emphasizes the importance of a holistic approach to healing that addresses the interconnectedness of mind, body, and spirit.

Keywords: Mental Health. Spiritual Healing. Psychological Well-being. Mindfulness. Meditation. Resilience. Trauma. Existential Well-being. Holistic Approach. Spiritual Practices.

1. Introduction

In recent decades, there has been increasing recognition of mental health's complexity, expanding beyond traditional psychological and pharmacological interventions. While cognitive-behavioral therapies and medication have been predominant, interest is growing in how spiritual practices can complement these approaches. Spiritual healing includes practices like mindfulness, meditation, prayer, and rituals, aiming to enhance psychological well-being through spiritual or religious means.

This interdisciplinary inquiry seeks to bridge spiritual and mental health domains, offering a holistic view of psychological healing. Research suggests spiritual practices address psychological needs conventional therapies may miss. For example, mindfulness meditation reduces anxiety and depression while improving emotional regulation [1]. Similarly, prayer and rituals foster connection, purpose, and resilience [2, 3], reflecting a broader understanding of mental health as multifaceted [4].

Recent reviews show spiritual practices positively influence mental health through mechanisms like stress reduction and emotional control [5, 6]. Yet, systematic integration into therapeutic paradigms remains underexplored [7]. This study aims to synthesize how practices such as mindfulness and prayer impact mental health, exploring stress response modulation, emotional regulation, and resilience development.

Ultimately, this research aims to detail how spirituality manages adversity and existential discomfort, advocating for holistic mental health care that integrates mind, body, and spirit. It highlights the potential for a comprehensive framework that includes spiritual interventions in mental health settings.

2. Materials and Methods

The This study investigates the relationship between mental health and spiritual healing through a comprehensive literature review and theoretical framework analysis. The research design includes data sources, inclusion

and exclusion criteria, data extraction methods, and analysis procedures to identify, evaluate, and synthesize existing empirical and theoretical studies.

2.1. Data Sources

A broad range of academic sources was used, including peer-reviewed journal articles, books, and conference proceedings from databases such as PubMed, PsycINFO, Google Scholar, JSTOR, and Web of Science. Search terms included combinations of keywords like "mental health," "spiritual healing," "mindfulness," "meditation," "prayer," "ceremonial practices," "emotional regulation," "resilience," "trauma," and "existential well-being."

2.2. Inclusion and Exclusion Criteria

Inclusion criteria encompassed studies published in English from 2000 onwards, empirical research articles, review papers, and theoretical frameworks that explore the effects of spiritual practices on mental health outcomes, including mindfulness, meditation, prayer, and ceremonial practices. Studies had to provide quantitative, qualitative, or mixed-methods data on the psychological impacts of spiritual practices. Exclusion criteria included articles not available in full text, non-peer-reviewed sources, studies focusing solely on religious practices without a direct connection to mental health outcomes, and research discussing general psychological therapies without addressing spiritual practices specifically.

2.3. Data Extraction

Data extraction followed a standardized process to ensure consistency and thoroughness. Information collected included study details (author(s), year of publication, study design), objectives, methods, results, theoretical frameworks, and conclusions about the effectiveness of spiritual practices in mental health interventions.

2.4. Data Analysis

Data was analyzed using a qualitative synthesis approach. Key steps included organizing data into thematic categories based on the type of spiritual practice and mental health outcome, performing thematic analysis to identify patterns and relationships among studies, and synthesizing findings to compare the effectiveness of various spiritual practices. This process integrated empirical data with theoretical insights to provide a comprehensive overview of the influence of spiritual practices on mental health.

2.5. Public Availability of Data

All data, including search results and extracted information, is available upon request. The literature search strategy, inclusion and exclusion criteria, and data extraction protocols are documented and can be provided for verification and replication of the study's findings.

2.6. Potential Restrictions

There are no significant restrictions on the availability of materials or information. However, some full-text articles may be behind paywalls. Readers can access these through institutional libraries or contact the authors for copies.

2.7. Data Availability Statement

All relevant data for this review are included in the main text and supplementary materials. Additional data will be provided upon reasonable request.

3. Results

This section presents findings from the literature on the relationship between mental health and spiritual healing, organized under four main subheadings: the impact of mindfulness and meditation, the role of prayer and ceremonial practices, the psychological mechanisms underlying spiritual practices, and the integration of spiritual interventions in mental health care.

3.1. Impact of Mindfulness and Meditation

A substantial body of evidence indicates that mindfulness and meditation practices positively affect mental health outcomes. Studies reviewed showed that mindfulness meditation significantly reduces symptoms of anxiety and depression and improves emotional regulation and overall psychological well-being [8, 9]. For instance, Goyal et al. (2014) conducted a meta-analysis of mindfulness-based stress reduction (MBSR) programs and found moderate to large effects on reducing anxiety and depression, with a mean effect size of 0.51 for anxiety and 0.55 for depression [10].

Interpretation: Mindfulness and meditation foster a heightened state of awareness and present-moment focus, which helps individuals manage stress and emotional difficulties. The reduction in anxiety and depression observed in these studies is likely due to increased self-awareness, improved emotional regulation, and a reduction in ruminative thinking patterns [11]. These practices encourage a non-judgmental awareness of thoughts and feelings, which can diminish the impact of negative cognitive patterns and improve mental health outcomes.

3.2. *Role of Prayer and Ceremonial Practices*

Research indicates that prayer and ceremonial practices are associated with various positive mental health outcomes. Studies show that prayer can enhance a sense of connection, provide emotional support, and promote coping strategies during times of stress and adversity [12, 13]. For example, a study by Pargament et al. (2001) demonstrated that prayer is associated with increased spiritual well-being and improved psychological adjustment to stressful life events [14]. Similarly, ceremonial practices, such as rituals and communal gatherings, have been linked to enhanced social support and emotional resilience [15].

Interpretation: Prayer and ceremonial practices offer individuals a means of expressing their spiritual beliefs and seeking solace through a higher power or community support. These practices help individuals find meaning in challenging circumstances, which contributes to improved mental health. The communal aspect of ceremonial practices fosters a sense of belonging and social support, which are crucial for emotional resilience and stress management [16].

3.3. *Psychological Mechanisms Underlying Spiritual Practices*

The review identified several psychological mechanisms through which spiritual practices impact mental health. Key mechanisms include stress response modulation, enhanced emotional control, and resilience development [17, 18]. For example, research by Carlson et al. (2004) found that mindfulness meditation can alter brain activity related to stress responses, leading to reduced stress and better emotional regulation [19]. Additionally, spiritual practices contribute to resilience by helping individuals find meaning and purpose in adversity [20].

Interpretation: Spiritual practices such as mindfulness and meditation directly influence psychological processes related to stress and emotional regulation. These practices can alter brain function and emotional responses, leading to improved mental health outcomes. The development of resilience through spiritual practices involves cultivating a sense of meaning and connection, which helps individuals cope with life's challenges more effectively [21].

3.4. *Integration of Spiritual Interventions in Mental Health Care*

The reviewed studies suggest that integrating spiritual interventions into traditional mental health care can offer a more holistic approach to treatment. Evidence supports that combining spiritual practices with conventional therapies can enhance treatment efficacy and address aspects of mental health that are not fully covered by psychological and pharmacological methods alone [22, 23]. For instance, a study by Williams et al. (2014) found that spiritual interventions used alongside standard psychotherapy improved treatment outcomes for patients with depression and anxiety [24].

Interpretation: The integration of spiritual practices into mental health care provides a more comprehensive approach to treatment by addressing the mind-body-spirit connection. This holistic model acknowledges that mental health is influenced by a range of factors, including spiritual beliefs and practices. By incorporating spiritual interventions, mental health care can be expanded to offer support that aligns with the individual's spiritual and existential needs, potentially leading to more effective and meaningful therapeutic outcomes [25].

4. Conclusions

This review demonstrates that spiritual practices such as mindfulness, meditation, prayer, and ceremonial rites significantly improve mental health outcomes by reducing anxiety and depression, enhancing emotional regulation, and fostering resilience. These findings support the hypothesis that integrating spiritual practices with conventional mental health therapies can offer a more holistic and effective approach to mental health care. Future research should explore the specific mechanisms through which these practices influence mental health and evaluate their effectiveness across diverse populations. Overall, spiritual practices hold promise as valuable complements to traditional mental health interventions, advocating for a more inclusive and comprehensive treatment framework.

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Data Availability Statement: Not applicable

Conflict of Interest: I declare no conflict of interest

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Chronic fatigue: relativity in nature

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Abstract: In Oriental Medicine (OM), loss of one's sense of purpose or drive can primarily stem from our Wood element. Ability to envision beyond oneself and enjoy what you are doing allows us to work doing a job we may not love but rather endure because of Wood's ability to envision the bigger picture. OM philosophy teaches that Water element generates Wood element. Sleep or downtime, stillness, and meditation are all Water activities by nature and nourish the need for movement. However, the complexities of the human experience require more explanation than a disharmony of Wood being the source of our fatigue. While chronic fatigue and burnout have theoretical explanations in OM, I would like to also discuss Dr. Shen's Systems Theory in parallel to current research and data regarding chronic fatigue in Western Medicine (WM). This approach lends even more clinical insight and explanation to the varied symptoms and underlying patterns accounting for fatigue, thus staying in accordance with the goal of all practitioners, diagnosing and effectively treating patients as individuals.

Keywords: Chronic fatigue, burnout, stress, Systems Theory, Shang Han Lun, HPA Axis, breathing techniques, Blood brain barrier

1. Introduction

Burnout, until recent years, has been viewed solely as an occupational phenomenon but in 2019, the World Health Organization added "burnout" as a result of chronic, unmanageable workplace stress to the International Classification of Diseases (ICD-11). Today the terms "burnout" and "chronic fatigue (CF)" are often synonymous, and it is clear that the issue is growing in severity and has seeped out of the workplace and into familial and societal structures. To this day there is no objective test for this condition, thus it remains a diagnosis of exclusion and also is enduring an uphill battle alongside cultural and societal mental health awareness.

The rise, prevalence, and cost, of burnout and chronic fatigue pose a serious threat to our overall health as well as integrity of the workforce and economy [1, 2].

2. Materials and Methods

Based on over fifty years of clinical experience and necessity, Dr. John H.F. Shen formulated the Systems theory that organized seemingly elusive symptoms that he encountered amongst patients that failed to belong to one categorical pattern, tongue, or pulse associated with particular disease in Oriental Medicine. He was able to classify them into four major systems- Circulatory, Digestive, Nervous, and Organ; with the premise that not just specific organs can dysfunction, rather entire functional systems can become disturbed.

These four systems are analogous to the layers of energy in the body proposed by Zhang Zhong-Jing in the Shang Han Lun (Discussion of Cold Damage). Written around the third century, Zhang introduced the progression of disease from superficial to deeper layers in the body; the six divisions starting with outermost are Tai Yang, Shao Yang, Yang Ming, Tai Yin, Shao Yin, and Jue Yin. Dr. Shen observed and assimilated Tai Yang energy with the nervous system, Shao Yang the circulatory system, Yang Ming the digestive system, and the last three layers of Tai Yin, Shao Yin, and Jue Yin are grouped together to form the organ system.

In terms of individual vulnerability, stress will bypass intact physiological systems and go after the weakest system within that particular individual. Stress, by nature, will first affect the outermost layer and move deeper. If there is equal integrity of all the systems and the nervous system (first layer) is intact there will be no psychological problems however the nervous innervations of the circulatory, digestive, and organ systems will be affected in that order. Further explanation of this particular aspect helps explain why individuals respond differently to the same conditions under extreme stress and as we discuss the various symptoms observed in these

systems, we are able to recognize similar symptoms varying across CF and burnout patients in Western Medicine cases, [4].

The nervous system reflects Tai Yang energy while drawing on the Kidney Essence that provides Marrow (substance) of the nervous system provided to the Heart. The Urinary Bladder is the outward Yang manifestation of the body's defensive (Wei Qi). The Small Intestine is known as the 'minister of information,' whose cognitive functions include the separation, absorption, and transformation of ideas. Tai Yang is regarded as the lightest fastest moving energy, comparable to autonomic and survival, i.e. shiver, sweat, vigilance, fear. Kidney provides material foundation of brain activity while the Heart energy executes more ephemeral activities of the mind and spirit. Therefore, there is some Tai Yang/Shao Yin confluence that deserves to be kept in mind when observing patients.

Clinically, circulatory system or Shao Yang disharmonies are more involved with movement of blood and less Qi. It is key to remember that Qi disorders are more general weakness and intermittent pain. In this system, there are two possible etiologies. First, the Circulatory system disharmony is secondary to an energy problem; there is deficient energy needed to drive to the Heart which stems from overwork or excessive physical exertion. The second is the circulatory system affecting the energy; events such as trauma, emotional shock, or any incident that would increase resistance through the structure. Despite the etiology, focus needs to be on unblocking stagnation in the channels and the chest in order to restore Heart function [4]. In the presentation of CF and burnout, the Shao Yang system is not supplied with adequate Blood and as an adaptive mechanism the body tells the mind it is fatigued in order to conserve energy.

The digestive system, Yang Ming is pivotal to our health as human beings; this system at its core is what keeps continue our daily functions as organisms. The Lungs digest mucus, the Stomach & Spleen works together to digest food, and the Urinary Bladder & Kidney digest water. This system takes the brunt impact of our lifestyle choices including irregular eating habits, eating when not hungry, ignoring appetite, eating too fast, eating poor diet, exercising to quickly after meals or vice versa, or eating while too emotionally stimulated, just to name a few. Eating irregularly disrupts the rhythmic cycle of enzyme excretion and peristalsis without the ability to appropriately monitor intervals of rest and activity within this intricate system. Current research in Western Medicine today has established the physiological link between the gut-brain axis and the correlated growth and decline of mental state and digestive health. The enteric nervous system (ENS), which is embedded in the lining of the gastrointestinal system and considered a subdivision of the ANS can operate independently of the brain and the spinal cord. Recently it became evident that the intestinal bacteria can affect physiology and inflammation within the CNS. The nervous system and the gastrointestinal tract are communicating through a bidirectional network of signaling pathways called the gut brain axis, which consists of multiple connections, including the vagus nerve (parasympathetic), the immune system, and bacterial metabolites. During dysbiosis (gut-microbial alteration-the patterns we just discussed), these pathways are dysregulated and associated with altered permeability of the blood-brain barrier (BBB) and neuroinflammation occurs [6]. The BBB is a structure of endothelial cells firmly held together with tight junctions; the BBB protects the brain from pathogens and unwanted immune reactions that could damage the neurons and their connections. The proposed links between this pathophysiology and brain disorders that lead to a degradation in cognitive abilities lends to further extrapolation to the relationship concerning the Stomach Luo and its ability to treat disturbances of the spirit. I personally would like to continue research in relation to the BBB and its microscopic influence on the macrocosm that is the human body, mind, and spirit.

The organ system, involving Jue Yin, Shao Yin & Tai Yin, there is great emphasis placed on the influence of the Liver, Heart, and Kidney in this system and their strong relation to the body's Yin. Generalized Yin deficiency results from an overworked mind; compounded with Liver Qi stagnation and heat that is caused by daily stresses. In response the body supplies additional Yin in hopes of eradicating the problem; over time the Yin is consumed. Long term Yin deficiency decreases organ metabolism at the cellular level diminishing the contribution of the organs to the overall energy to the body. The heat from Yin deficiency is of no metabolic use in the body, therefore is expelled by feces, urine, and sweat [3]. Research can agree that CF may be caused by a dysfunction of the stress system. Recently there has been a common discovery regarding hypofunction of the Hypothalamic-Pituitary-Adrenal Axis; interestingly enough, it is a parallel to the correspondence and functions of the Liver, Heart, and Kidney systems that have been discussed for thousands of years in Oriental Medicine. The HPA Axis is a major component of the homeostatic response that serves as a neuroendocrine mechanism that mediates the effects of

stressors by regulating numerous physiological processes such as metabolism, immune responses, and the autonomic nervous system. To quickly review the functions of these structures, the Hypothalamus is the body's smart control coordinating center, responsible for body temperature, sleep/wake cycle, and hunger; its main job is to keep your body in homeostasis. This structure is considered the main link between your endocrine and nervous system. Pituitary (Anterior) This gland has the ability to make, store, and release its own hormones that are mainly involved in regulating growth, reproduction, and stress. Most commonly include prolactin (PRL), growth hormone (GH), adrenocorticotropic hormone (ACTH), luteinizing hormone (LH), follicle stimulating hormone (FSH), and thyroid stimulating hormone (TSH). Adrenals are triangular-shaped glands on top of each kidney, their function is to produce hormones that regulate metabolism, the immune system, blood pressure, and response to stress. The sleep-wake cycle is in direct control of the adrenal gland as well. Hypofunction of the HPA axis is an example of the Intertransforming nature of all things as discussed in OM theory; chronic overuse and generation of heat will eventually lead to weakening and collapse of a system.

3. Results

In a case of nervous system weak one will experience fatigue, lack of concentration or memory, despite being very creative and bright, vague shifting pains, shyness, emotional vulnerabilities, one feels unstable about their childhood), lifelong history of neurasthenia (lassitude, fatigue, irritability, and headache). When the nervous system is tense, individuals will report mental and physical tension while under stress, intolerance of heat, mild headaches, difficulty falling asleep, eye and/or skin dryness, and easy to sweat [4].

Hypervigilance is a common pattern found today in almost anyone living in a large city or with a need to be vigilant. Over time this will create internal heat from excess and degrees of stagnation from one's need to suppress spontaneity and emotional response. This will directly affect the Liver as it creates heat to overcome this stagnation; if the circulatory system is vulnerable, heat can also easily progress deeper and affect the blood and blood vessels.

Disharmony in the Shao Yang as a source of fatigue, patients may present with cold extremities and swelling of a persistent nature, easily angered or quick tempered, fluctuating waves of extreme fatigue, cold hands and feet, migrating joint pain, severe anxiety and depersonalization. A clinical approach focused towards unblocking the chest and nourishing the Heart function should be considered according to Dr. Chen's theory.

When the Yang Ming system is in disharmony symptoms will include a fluctuating appetite, noticeable change to bowel movements or digestion, mucus or pressure in the chest or throat, injury to Stomach Yin will also be observed. While the symptoms here are dealing less with fatigue, we need to always keep in mind that the Digestive system (Earth) nourishes all the other systems, and our eating habits are commonly overlooked in the assessment of our mental health and vital energy.

The organ system involving Tai Yin, Shao Yin, and Jue Yin involve symptoms of spontaneous sweat, bouts of sudden and extreme fatigue, aversion to cold, infrequent bowel movements, chronic illness and infection with difficult recovery. This level of fatigue and physical stress on the patient will typically be advanced and severe. In comparison, symptoms of overuse and the consequential hypofunction of the HPA axis include fatigue (regardless of a good night's sleep or after minimal exertion), difficulty falling or staying asleep, mood dysregulation including anxiety or depression, "brain fog" or difficulty concentrating & impaired memory, irregular appetite including an increase in cravings for sugar or salt along with possible digestive issues, hormonal imbalances such as PMS or changes in sex drive. Other symptoms can include noticeable increase in inflammation, neuralgias, myalgias, poor immune response, and weak circulation [8].

Digestion, blood circulation, and sleep behaviors are part of the body's cyclic patterns; breathing is an obvious source of vitality and has strong correlations to our environment however remains overlooked and rarely practiced until recently in the West. Dr. Andrew Huberman is a renowned neuroscientist at Stanford University and in the past few years has brought a great deal of awareness to the science behind breathing, specifically the sigh. When you breathe in through your nose until you reach full capacity, then take another short nasal breath in, that extra pull inwards will allow your lungs to completely stretch. When followed with a long, slow exhalation, the body is able to clear out residual carbon dioxide from the alveoli (tiny air sacs in the lung) and promote oxygen uptake which allows for optimal function. The role of breathing is not exclusionary to ventilatory functions; breathing is in fact one of the most centrally integrated motor behaviors with many modulatory and

sensory roles that are highly state dependent making its neuronal functions equally as important. Practical applications of breathing include stress management, relaxation techniques, and simply becoming mindful of the deep, intentional breaths you use to benefit your physiology such as the “4-7-8” technique. A key finding in his research is that the physiological sighs act as a reset button for the respiratory and nervous systems; this stems from maintaining a vital balance between the sympathetic and parasympathetic branches of our autonomic nervous system. In a fascinating parallel, Daoist breathing exercises have been practiced and cultivated for over 2000 years, the focus of these practices is designed to activate the diaphragm muscle, expand the lungs, and invoke the body’s innate relaxation response; four major types of breathing include natural breathing, reverse breathing, Dantian breathing, and embryonic breathing [7].

4. Discussion and Conclusion

The discussion of chronic fatigue and burnout in our cultures has existed for centuries. Oriental Medicine philosophy embraces the inseparability of body and mind, much like Yin and Yang. Taking into consideration the systems theory of Dr. Chen specifically we can begin drawing parallels to common physiological processes and factors that cause chronic fatigue in WM. The study of bioenergetics, psychology neurology and Oriental Medicine have a common bond and much to contribute to the further research on the continuum of health and disease while achieving practical understanding of internal medicine and fusion of numerical data and imaging.

What I am proposing is the closer study and consideration of the digestive system, nervous system, circulatory system, and HPA axis in the treatment of Chronic Fatigue and burnout. This approach allows for cultural transmission as we are able to clinically draw and apply parallels between Oriental and Western Medicine. More clinical research and additional point and herbal prescriptions need to be compiled in order to further apply this theory and test its efficacy. This is not meant to be an all-encapsulating solution to the prevalent issue, rather a discussion of a lens that may bring this natural phenomenon into focus, to master simplicity and control complexity. Thus, allowing us to enhance the functional ability of life while promoting and restoring health.

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The Effect of Elementary school students' Participation in Jumping rope exercise on Stress Relief and Self-confidence Improvement

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Abstract: The purpose of this study was to provide empirical data by investigating the effect of jumping rope exercise on stress relief and self-confidence improvement among elementary school students. For the study, a survey was conducted on 395 elementary school students who are doing rope jumping exercises. Exploratory factor analysis, one-variate analysis, stress relief, and regression analysis were performed using the SPSS Win 22.0 program to validate this study. There was a significant difference in the problem-solving and effort-dissolving behavior for stress-relief by gender," said. As a result of relieving stress over the training period, there was a significant difference in effort behavior. A significant difference was found in the problem-solving and effort-dissolving behavior of the average number of times a jump motion was performed once. There was a significant difference in confidence and positive learning by gender," said. A significant difference was shown in confidence in improving confidence based on the average number of people in the first run. In conclusion, it has been shown that jumping rope exercises have an effect on stress relief. It has also been shown to affect self-confidence and positive acquisition. It should be applied to middle and high schools and the general public to conduct research on the effects of jumping rope exercise on health, stress relief, and self-confidence.

Keywords: jumping rope, exercise, stress relief, self-confidence, improvement

1. Introduction

Modern society has brought much convenience and development to human life through the rapid development of science and technology, but at the same time, there are various factors that affect the mental health of modern people. Mental health problems can have different causes, such as excessive stress, social isolation, and digital dependence, and can have a negative impact not only on the individual's life, but also on the family, community, and society. This leads to mental problems such as depression and anxiety, and digital dependence is also a serious problem, especially manifesting as Internet addiction among teenagers. Moore & Stevenson [1], classified self-confidence into a sub-concept that consists of self-efficacy along with self-concept and self-esteem. Confidence does not refer to the roles and functions that an individual possesses, but rather refers to what a person can do with those functions. It means to do something, and in a general sense, it is said that confidence, which is the psychological state of an individual who believes that he or she can successfully perform something, means an individual's confidence in success. Self-efficacy, which is necessary to improve confidence, is a concept based on social learning theory. According to Bandura [2], self-efficacy can motivate and change individual activities and have a positive effect on behavior. This study provides empirical data by identifying the impact of rope-jumping exercise on relieving stress and improving self-confidence in elementary school students, thereby enabling elementary school students to improve their quality of life through healthy leisure activities through rope-jumping exercise. The purpose is to promote the revitalization of people's rope jumping exercise.

2. Materials and Methods

The subjects of this study were elementary school students who consistently practice jumping rope more than three times a week among the trainees at five training centers that teach rope jumping exercise in the Gyeonggi-do region, and a total of 400 samples were collected. Among the collected data, excluding 5 data that were judged to have insufficient responses, a final set of 395 data (male: 187 people, female: 208 people) was used for analysis.

In this study, Son Moo-kyung's tool [3] was modified and supplemented to measure stress relief. As a result of using the 16 variables related to stress relief in this study in factor analysis, the Cronbach α coefficient was .93. To measure the improvement in self-confidence, the self-efficacy tool developed by Kin and Cha was used, modified and supplemented by Shin Seon-young [4]. As a result of using the 14 variables related to self-confidence improvement in this study in factor analysis, the Cronbach α coefficient was 0.94. The collected data were processed using the following analysis techniques using the SPSS Win 22.0 program. First, frequency analysis was conducted on questions about personal characteristics to determine the distribution of respondents. Second, exploratory factor analysis (EFA) was conducted to verify the validity of the measurement tool, and Cronbach's coefficient was calculated to verify the reliability of factors separated into the same group. Third, one-way analysis of variance was conducted to verify differences between groups. Fourth, regression analysis was conducted to investigate the relationship between stress relief and confidence improvement in students who participated in rope jumping exercises.

3. Results

3.1. Differences in Relieving Stress

3.1.1. Differences in stress relief by gender

The results of one-way analysis of variance on stress relief according to gender are as follows (Table 1). As a result of conducting a one-way analysis of variance on stress relief according to gender, there was a significant difference in problem solving and effort behavior for stress relief between rope jumping exercise ($p < 0.05$).

Table 1. Differences in stress relief by gender

Subjects		SS	DF	SD	F
Problem solving	Between groups	13.588	4	3.397	3.484*
	Within groups	374.412	3844	0.975	
	total	388.000	388		
Effort action	Between groups	10.369	4	2.592	2.636*
	Within groups	377.631	384	0.963	
	total	388.000	388		

* $p < 0.05$

3.1.2. Differences in stress relief depending on training period

Table 2. Differences in stress relief depending on training period

Subjects		SS	DF	SD	F
Problem solving	Between groups	5.688	4	1.422	1.428
	Within groups	382.312	384.996		
	total	388.000	388		
Effort action	Between groups	123.10	4	3.078	3.146*
	Within groups	375.690	384	0.978	
	total	388.000	388		

* $p < 0.05$

The results of one-way analysis of variance on stress relief according to the training period are shown in Table 2. As a result of conducting a one-way analysis of variance on stress relief according to the training period, there was no significant difference in problem solving for stress relief between the rope jumping exercise and the training period. However, there was a significant difference in effort behavior ($p < 0.05$).

3.2. Difference in Increased Confidence

3.2.1. Differences in self-confidence improvement by gender

The results of one-way analysis of variance on confidence by gender are shown in Table 3. As a result of conducting a one-way analysis of variance on self-confidence by gender, there was a significant difference in confidence and positive acquisition of self-confidence between rope jumping exercises ($p < 0.05$).

Table 3. Differences in self-confidence improvement by gender

Subjects		SS	DF	SD	F
Confidence	Between groups	13.588	4	3.397	3.484*
	Within groups	374.412	384	0.975	
	total	388.000	388		
Positive acquisition	Between groups	10.369	4	2.592	2.636*
	Within groups	377.631	384	0.963	
	total	388.000	388		

* $p < 0.05$

3.2.2. Differences in confidence improvement depending on training period

The results of one-way analysis of variance on confidence according to training period are shown in Table 4. As a result of conducting a one-way analysis of variance on confidence according to the training period, there was a significant difference in confidence in the rope jumping exercise according to the training period ($p < 0.05$). However, no significant difference was found in positive acquisition.

Table 4. Differences in confidence improvement depending on training period

Subjects		SS	DF	SD	F
Confidence	Between groups	8.859	4	2.215	0.064*
	Within groups	378.141	383	0.987	
	total	381.000	387		
Positive acquisition	Between groups	2.743	4	0.686	0.604
	Within groups	384.257	383	1.003	
	total	387.000	387		

* $p < 0.05$

3.3. Impact on relieving stress and improving confidence

3.3.1. The effect of rope jumping exercise on relieving stress

The results of a regression analysis conducted to determine the effect of rope jumping exercise on problem solving and effort behavior, which are sub-variables of stress relief, are shown in Table 5. As for the effect on problem solving and effort behavior, which are stress relief subvariables, the total variance in explanatory power (R^2) was 0.438, and the beta of problem solving, which is a stress relief subvariable, was significant at $\beta = 0.564$ ($p < 0.000$). There was a difference, and there was a significant difference with beta of effort behavior $\beta = 0.349$ ($p < 0.000$). Therefore, rope jumping exercise was found to have an effect on problem solving and effort behavior, which are sub-variables of stress relief.

Table 5. Effects on Stress Relief

Variable	B	SE	β	t	P
Constant	0.007	0.038		0.181	0.857
Problem solving	0.564	0.038	0.564	14.723	0.000
Effort action	0.349	0.038	0.349	9.118	0.000
R2 = 0.438			F = 149.363		

3.3.2. The impact of rope jumping exercise on improving self-confidence

The results of the regression analysis conducted to determine the effect of rope jumping exercise on the confidence improvement sub-variables of confidence and positive acquisition are shown in Table 6. As for the effect on self-confidence and positive acquisition, which are sub-variables of self-confidence, the overall variance in explanatory power (R2) was 0.565, and the beta of self-confidence, which was a sub-variable of self-confidence, was significant at 0.529 ($p < 0.000$). There was a significant difference with beta of positive acquisition = 0.534 ($p < 0.000$). Therefore, rope jumping exercise appeared to have an effect on self-confidence and positive acquisition, which are sub-variables of confidence improvement.

Table 6. Improving self-confidence

Subjects	B	SE	β	t	p
Constant	-0.005	0.034		-0.150	0.880
Confidence	0.530	0.034	0.529	15.661	0.000
Positive acquisition	0.538	0.034	0.534	15.822	0.000
R2 = 0.565			F = 247.808		

4. Discussion

This study analyzed the impact of elementary school students' rope jumping exercise on relieving stress and improving self-confidence. It was found that jumping rope exercise had an effect on relieving stress depending on gender and sociodemographic characteristics. This is the same result as a previous study [5], which found that stress levels decreased significantly after participating in the rope jumping program. Participation in physical activity helps with mental health and is effective in relieving personal stress, and rope jumping exercise has been shown to not only improve one's problem-solving skills but also to practice behavior for effort.

As a result of a study on the effect of rope jumping exercise on improving self-confidence, significant differences were found in confidence and positive acquisition, and rope jumping exercise was found to have an effect on confidence depending on gender. The rope jumping exercise is a result of positive learning that builds children's confidence and actively participates in the rope jumping exercise. These results are identical to the research results of Minhyung Kim [6], who found that rope jumping activities improved self-esteem in elementary school students.

5. Conclusions

This study aims to determine the impact of rope jumping exercise on relieving stress and improving self-confidence in elementary school students. The subject of this study was set as the population of trainees belonging to a rope jumping training center located in Gyeonggi-do who consistently practice jumping rope more than three times a week, and 395 people were selected through sampling. First, as a result of analyzing the impact of rope jumping exercise on relieving stress in elementary school students, significant differences were found in problem solving and effort behavior. As a result of analyzing stress relief according to gender, significant differences were found in problem solving and effort behavior, and no significant differences were found in problem solving and

effort behavior for stress relief according to grade. There was no difference in stress relief depending on the training period, but there was a significant difference in stress relief depending on the average number of sessions performed per session.

Second, as a result of analyzing the effect of rope jumping exercise on the self-confidence of elementary school students, there was a significant difference in confidence improvement and positive acquisition. As a result of examining the effect of rope jumping exercise on confidence according to gender, significant differences were found in confidence and positive acquisition, and there was no significant difference in confidence improvement by grade. In addition, there was a significant difference in confidence in the rope jumping exercise according to the training period, and a significant difference in confidence in confidence improvement according to the average number of times performed per session.

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Ideal end-of-life care for terminally ill patients with unclear consciousness

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Abstract: End of Life Care (EoLC) is a form of care that supports terminally ill patients to spend the rest of their lives as meaningfully and comfortably as possible, and rather than simply focusing on prolonging their lives, it focuses on maintaining the dignity of patients and improving the quality of life. Although it is very difficult to define end-stage patients, This Study was intended to investigate the elements of ideal EoLC by limiting the case of caring for patients with unclear consciousness and approaching death. Through the survey, the need for sufficient communication between medical personnel and their families, psychological and spiritual support, and hospital system improvement was emphasized. The results of the study suggest that sufficient communication and compassionate and comprehensive care between medical personnel and their families are important for both patients and their families to live an emotionally stable and peaceful process of death.

Keywords: End of Life Care, Spiritual Care, Quality of life, communication

1. Introduction

End of Life Care(EoLC) is designed to support terminally ill patients in living their remaining days with dignity and comfort. Unlike treatments aimed solely at prolonging life, EoLC prioritizes the patient's quality of life and overall well-being [1]. This care model also extends its focus to the patient's family, ensuring they receive the support needed to cope with the emotional and psychological challenges during and after the patient's passing.

The significance of EoLC becomes particularly evident when dealing with patients who are nearing death and have diminished consciousness [2]. In such cases, clear and compassionate communication with the patient's family about the patient's condition and the dying process is crucial. It not only helps the family understand and prepare for the impending loss but also contributes to their psychological stability and acceptance of the situation.

This study aims to explore the elements of ideal EoLC for end-stage patients with unclear consciousness from the perspective of doctors and nurses in hospitals who believe in spiritual afterlife. Through detailed surveys, we identify key factors that contribute to effective EoLC and suggest ways to improve the hospital system to better support these patients and their families.

2. Materials and Methods

2.1. Participants

The study surveyed 48 healthcare professionals (10 doctors and 38 nurses) from HJ Magnolia International Hospital, all of whom believe in a spiritual afterlife and have experience in providing EoLC to patients with diminished consciousness.

2.2. Survey Design

The survey comprised multiple-choice and open-ended questions, focusing on the following areas:

1. Professional background and experience in EoLC.
2. Importance of explaining the patient's condition and dying process to the family.
3. Frequency and methods of communication with the family.
4. Psychological and spiritual support strategies for the patient and family.
5. Perceived contributions of spiritual comfort to the family's emotional stability.
6. Elements deemed essential for providing ideal EoLC.
7. Recommendations for hospital improvements to enhance EoLC.

2.3. Data Collection and Analysis

The survey responses were collected and analyzed to identify common themes and significant findings. Quantitative data were summarized using descriptive statistics, while qualitative data from open-ended questions were analyzed to extract meaningful insights and recommendations.

3. Results

3.1. Demographics

1. Profession: 10 doctors, 38 nurses
2. Experience in Healthcare: 9 with 1-5 years, 14 with 6-15 years, 25 with over 16 years
3. Experience in EoLC for patients with diminished consciousness: 37 had experience, 11 did not

3.2. Importance of Communication:

43 respondents emphasized that explaining the patient's condition and dying process to the family is "very important," while 5 considered it "important."

3.3. Reasons for Communication:

The primary reason for thorough communication was to ensure the family's psychological stability and positive beliefs about the afterlife (26 responses), followed by ensuring the patient's comfortable death (17 responses), and building trust with medical staff (4 responses) (Figure 1).

Why communication (explanation) is important

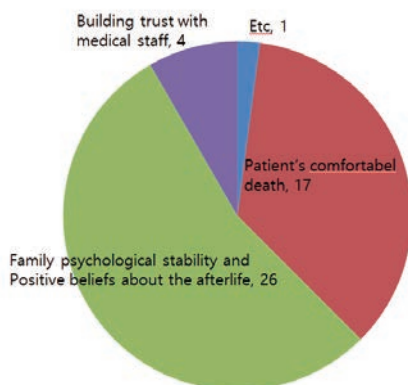


Figure 1. Reasons for communication.

3.4. Frequency of Communication:

Most respondents (36) believed in explaining the patient's condition to the family as often as necessary, while 10 supported occasional explanations, and 2 suggested a one-time explanation during initial consultation.

3.5. Contribution to Emotional Stability:

29 respondents felt that sufficient explanations significantly contribute to the family's acceptance and gratitude, while 17 agreed it contributes "a lot," and 2 considered it "moderate (Figure 2)."

Impact of providing explanation and understanding

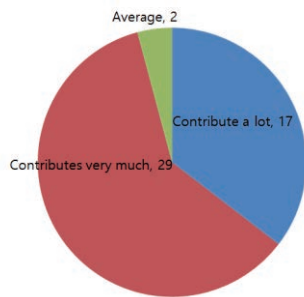


Figure 2. Impact of providing explanation and Understanding.

How to provide support

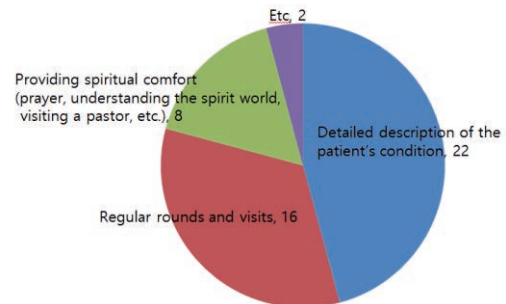


Figure 3. How to provide support.

3.6. Support Strategies:

Detailed explanations of the patient's condition (22 responses) and regular visits (16 responses) were the most commonly used support strategies, with some also providing spiritual comfort through prayer and pastoral visits (8 responses) (Figure 3).

3.7. Importance of Spiritual Comfort:

40 respondents believed that providing reassurance about the afterlife contributes significantly to the emotional stability of both the patient and family, while 7 felt it had a moderate impact, and 1 saw minimal contribution.

3.8. Essential Elements of Ideal EoLC (Figure 4):

1. Emotional and spiritual support for the family (36 responses)
2. Physical pain management for the patient (33 responses)
3. Continuous communication and cooperation between medical staff and the family (25 responses)
4. Professional medical knowledge and skills (9 responses)

3.9. Recommendations for Hospital Improvements (Figure 5):

1. Enhanced education programs for EoLC (35 responses)
2. Improved communication and cooperation among staff (25 responses)
3. Adequate allocation of time and resources (24 responses)
4. Systematic and institutional improvements (25 responses)

Important factors

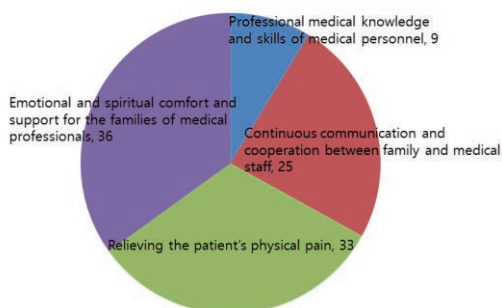


Figure 4. Important factors.

Improvements in the hospital

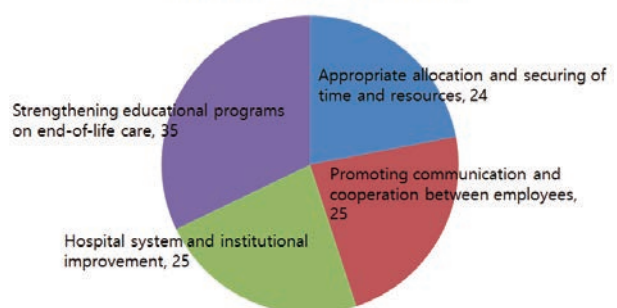


Figure 5. Important in the hospital.

4. Discussion

The results emphasize the important role of communication and emotional support in providing ideal EoLC. Effective communication helps families understand and accept the process of dying, thereby contributing to reducing anxiety and developing a sense of appreciation. In addition, spiritual support plays an important role in the emotional stability of both patients and families, which is consistent with the beliefs of medical professionals who responded to the questionnaire. The author also experienced through many clinical cases that when the patient's consciousness is not clear, it is very important to fully explain the patient's condition to the family guarding the patient from time to time and to better understand the pre-death process. In addition, I think that comfort that one can go to a good spiritual world after death is important for the psychological stability of the family, and that it can be ideal care if one can face the entire process of end-of-life care and death with gratitude.

This study also highlights the need for systematic improvement in hospital settings. This includes better education and training for healthcare providers, enhanced communication strategies, and sufficient resource allocation to support comprehensive EoLC.

4.1. Importance of Communication

The majority of respondents (43) considered communication about the patient's condition and the dying process to be "very important," underscoring the pivotal role of communication in EoLC. Clear explanations help families understand and accept the patient's condition, reducing their anxiety and fostering trust between the family and the healthcare team [3]. Frequent updates and honest answers to family questions alleviate uncertainty and enhance the family's sense of involvement and control.

4.2. Need for Psychological and Spiritual Support

Most respondents emphasized the necessity of psychological and spiritual support in EoLC. Providing psychological stability and positive beliefs about the afterlife helps families cope with the patient's impending death and contributes to long-term emotional well-being [4]. This support is particularly crucial after the patient's death, helping families navigate their grief and find peace. Regular visits and detailed explanations of the patient's condition, along with spiritual comfort such as prayer and pastoral visits, were identified as effective support strategies.

4.3. Role of Spiritual Comfort

The significant positive impact of spiritual comfort on the emotional stability of both patients and families cannot be overlooked. Forty respondents believed that reassurance about the afterlife contributes greatly to emotional stability, highlighting the importance of incorporating spiritual support into EoLC. This support helps patients and families approach the dying process with peace and meaning.

4.4. Need for Hospital System Improvements

Improving hospital systems is another critical area highlighted by respondents. Enhancing education programs for EoLC, promoting communication and cooperation among staff, ensuring adequate allocation of time and resources, and making systematic and institutional improvements are essential steps [5]. Such improvements create an environment where healthcare providers can deliver high-quality care to patients and families. Structured education programs on EoLC can enhance the professionalism of healthcare providers and ensure that they can offer comprehensive and compassionate care.

4.5. Comprehensive Approach

An ideal EoLC approach requires a comprehensive, multifaceted strategy. The study identified key elements such as physical pain management, emotional and spiritual support for the family, continuous communication, and professional medical knowledge and skills. Addressing these elements collectively helps patients and families accept and navigate the dying process with gratitude and peace [6]. Hospitals should consider these elements to provide patient-centered, holistic care.

4.6. Policy Recommendations

The study also includes policy recommendations for improving EoLC. Raising awareness about EoLC, supporting policies and systems that integrate emotional and spiritual support into healthcare, and providing systematic training and education for healthcare providers are crucial. Ensuring healthcare providers are well-equipped to deliver comprehensive EoLC can significantly improve the quality of care for terminally ill patients and their families.

5. Conclusions

Ideal end-of-life care for terminally ill patients with unclear consciousness includes a multifaceted approach that prioritizes sufficient communication between medical personnel and families, emotional and spiritual support, and professional medical care. By addressing these key factors and implementing systematic improvements, healthcare providers can improve the quality of life for both patients and their families at the final stage of their lives. To this end, hospitals should focus on creating a comprehensive medical support and care environment through policy and institutional improvements, strengthening the capacity of healthcare providers to meet the needs of patients and families, and adjusting the educational environment.

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A future prospect of Korean medical care and the mission of HJ Magnolia International Medical Center based on Unification Medical Science

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Abstract: As South Korea's rapid economic growth progresses and it becomes wealthier both economically and materially, various issues have emerged, including complexities in human relationships, mental health problems such as depression, school violence, bullying, suicide, population aging, and declining birth rates. With the rapid aging of South Korea's population, the proportion of people aged 65 and over currently stands at 18.4% of the total population, and it is estimated to reach 24.6% by 2033. As we face an aging society, it is crucial to seriously consider how to live healthily in both mind and body, and how and where to approach the end of life. This time, by referring to the medical realities of Japan, which is already ahead in dealing with an aging society, I would like to examine the current situation and issues in South Korea and determine the direction we should take. To address these problems, I propose that the public health center in Gapyeong County and HJ Magnolia International medical center take the lead in establishing a community-based comprehensive care system model in Gapyeong County.

Keywords: regional comprehensive care system, home medical care, end-of life care

1. Introduction

End Korea's rapid growth began in the 1960s, but it is the sustained growth over the past 20-30 years, accompanied by rapid technological innovations, that has brought about various issues. These include the complexity of human relationships, mental health problems such as depression, school violence, bullying, suicide, an aging population, and declining birth rates. Amid Korea's rapidly advancing aging society, it is estimated that in 2024, 18.4% of the population over 65 years old will make up about 5.13 million of the total population. By 2033, this percentage is expected to rise to 24.6% of the population, approximately 4.99 million people. In such an aging society, maintaining both physical and mental health in daily life and addressing the crucial issue of where and how one spends their final days becomes paramount. According to mortality statistics from 2021, the proportion of elderly people, particularly those over 80 years old, passing away in medical institutions in Korea has increased significantly from 63.3% in 2010 to 78.2% in 2019, a rise of 15%. At the same time, the increasing medical expenses for the elderly have become a significant concern (Figure 1).

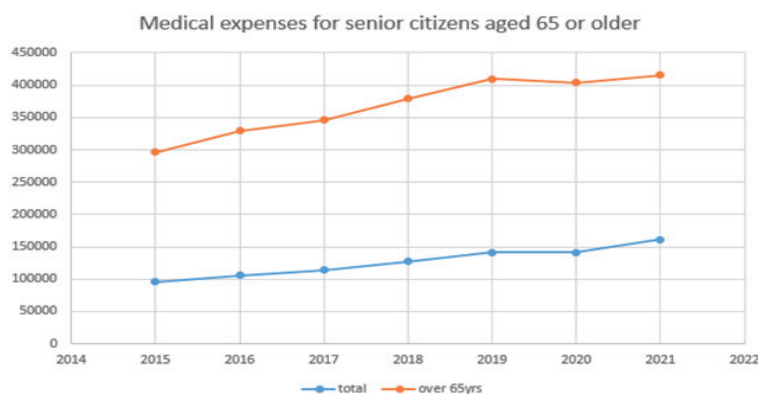


Figure 1. Medical expenses for senior citizens aged 65 or older.

On the other hand, a 2020 survey on the elderly revealed that 57.6% of seniors prefer to pass away at home (Figure 2). However, due to changes in family caregiving attitudes and household structures, receiving end-of-life care at home without any external help has become increasingly difficult. One proposed solution to these issues is the necessity of home healthcare and home visit medical services.

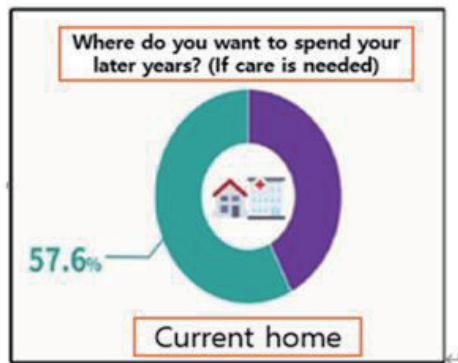


Figure 2. Where do you want to spend your later years?

By referring to the current state of home healthcare and nursing care in Japan, which became an aging society before Korea, we aim to examine the progress of home healthcare in Korea and identify what issues need to be addressed moving forward.

2. Materials and Methods

2.1. The Current State and Challenges of Home Healthcare and Home Visit Medical Services in Korea

In December 2019, Korea initiated a pilot project for primary medical home visit reimbursement, and by January 2023, the pilot project was expanded to 28 medical institutions nationwide. However, several challenges remain.

2.1.1. Lack of Awareness Among Patients and Families:

Many patients and their families are not well-informed about home visit medical services, leading to underutilization. When patients become immobile, their caregivers often go to the university hospital they previously visited to get prescriptions on their behalf. The prescribing doctors, unfamiliar with the patient's current condition, may not provide appropriate treatment. Non-medical family members may also miss early signs of conditions like pneumonia, urinary tract infections, or pressure sores, leading to repeated emergency room visits and hospital admissions. Educating families through home visits and providing necessary treatments beforehand could reduce these issues.

2.1.2. Need for More Doctors Involved in Home Visit Medical Services

The low reimbursement rates for home visit services make it challenging to attract more doctors. Many doctors involved in this program are clinic-based and often conduct home visits during lunch breaks, late evenings, or weekends, remaining on alert for emergencies. The extensive paperwork and reporting requirements further discourage doctors from participating in the program.

2.1.3. Necessity to Improve Medical Laws (Table 1)

Current Korean medical laws stipulate that medical activities can only be performed in medical institutions. To advance home healthcare effectively, the laws need to be amended to allow treatments at home. In Japan, various treatment fees and additional reimbursements for end-of-life care at home are included in the visit fees. Currently, in Korea, home visit medical services receive visit consultation fees, basic home healthcare fees, and additional nursing fees, but they operate under a comprehensive system without performing medical procedures. Currently, only qualified home care nurses can provide home treatments, but there is a shortage of these nurses. Expanding the scope to include visiting nurses is necessary. Additionally, most of the assistants accompanying doctors from primary medical institutions are nursing assistants, who are not eligible for reimbursement unless they are registered nurses. Furthermore, there are limitations such as only being able to claim visit consultation fees up to

100 times per month per doctor. Addressing these issues requires revising medical laws and creating a more efficient and comprehensive home visit medical system.

Table 1. Comparison of home visit medical service reimbursements in Korea and Japan

Reimbursements for Home Visit Medical Services (Korea)	
•	Home Visit Consultation Fee: 128,960 KRW/time
•	Oriental Dr. : 102550 KRW/time
•	Basic Fee for Home Medical Care: 140000 KRW/month
•	Sustained management fee : 60000 KRW/ every 6 months
•	Additional nursing fee 51110 KRW (until 3 times)
Reimbursements for Home Visit Medical Services (Japan)	
•	Home Visit Consultation Fee: 41830 JPY/month (1time visit)
•	75760 JPY/month (2 times visit)
•	Palliative Care Requirement: 92,000 JPY/month
•	Home Visit with Combined Nursing: 80,000 JPY/month (Basic Home Visit Consultation + Home Nursing)
•	Palliative Care + Combined Nursing: 120,000 JPY/month

2.2. Construction of a Regional Comprehensive Care System Medical Model

The As of 2024, Gapyeong County in Gyeonggi Province has a population of approximately 60,233, with the elderly population making up about 25.2%. The area spans approximately 843.84 km², with a population density of about 71.4 people/km², indicating a highly aged and sparsely populated region. Our hospital, HJ Magnolia International medical center, is located in the eastern part of this region. There are no university hospitals or other secondary hospitals in this area. However, it is about 30 minutes away from Seoul's Hyundai Asan Hospital and about 40 minutes from Chuncheon's 2 university hospitals in Gangwon Province, with our hospital located roughly in between.

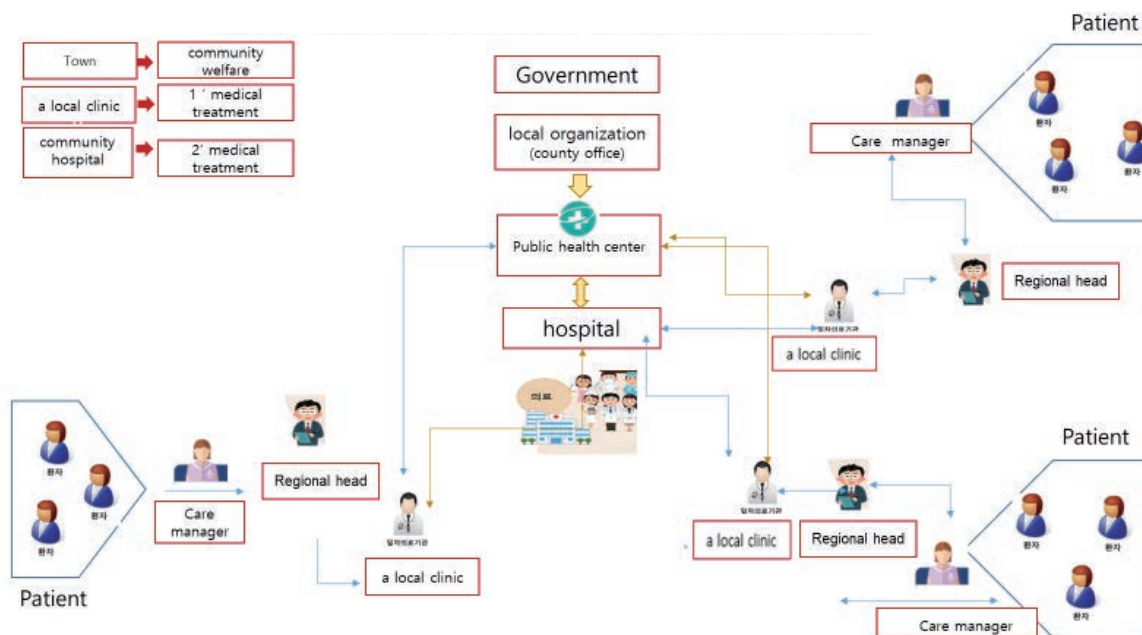


Figure 3. Construction of a regional comprehensive care system.

I propose the construction of a regional comprehensive care system medical model in collaboration with the local health center (Figure 3). This model will focus on cancer patients and other chronic disease patients residing in this region, for whom active treatment at university hospitals is no longer feasible, and particularly for those who find it difficult to move and visit hospitals. The model aims to continue the care provided by university hospitals and to implement home visit medical services, nursing, caregiving, and home healthcare. Additionally, it seeks to establish a system for the prevention, health management, and treatment of the Gapyeong county residents.

This initiative cannot be achieved solely by the health center and our hospital. Primary medical institutions in Gapyeong County must play a crucial role. It is essential to build a regional network consisting of 1) public institutions (health centers, local governments, health insurance corporations), 2) private medical institutions (primary clinics, specialized clinics, hospitals, long-term care- hospitals), and 3) private support agencies (nursing homes, home welfare support centers, home nursing centers).

Additionally, South Korea excels in integrating IT into daily life more than any other country. Therefore, leveraging telemedicine and AI robots would be beneficial. Incorporating traditional Korean medicine more extensively into visiting medical services is also expected to significantly improve the quality of treatment. As individuals, family members, and community residents, people desire to be healthy in both body and mind. For those without families, community members can become their family, creating a regional network where our hospital and local doctors in Gapyeong County work together to form an extended family system. One example of such an initiative is the suicide prevention intensive management agency in Gapyeong County, led by a university hospital's psychiatric specialist. This agency has reduced the suicide rate from 60.5 per 100,000 people in 2010 to 20 per 100,000 people in 2019 through the efforts of the Mental Health and Welfare Center in collaboration with experts, rather than hospital treatment alone. There are numerous problems to solve in building this system. However, if each institution takes on specific roles and focuses on the health management of each resident, various social problems that accompany rapid growth can be gradually resolved. Gapyeong County is an ideal environment for creating such a model, which can then be expanded nationwide.

3. Discussion and Conclusion

As we face an aging society, it is crucial to seriously consider how to live healthily in both mind and body, and how and where to approach the end of life. South Korea has achieved rapid economic growth and has become wealthy both economically and materially. However, this has brought about various social issues, particularly mental health problems. Family, friends, and community members are expected to play an important role in solving these issues. Home medical care and visiting medical care are not only necessary because it is difficult for physically disabled individuals to go to hospitals or to reduce medical expenses, but also as a key solution to the various problems arising in the background of the high-growth era. Therefore, I propose that the public health center in Gapyeong County and HJ Magnolia International medical center take the lead in establishing a community-based comprehensive care system medical model in Gapyeong County. By doing so, we hope to restore South Korea's traditional family relationships and the world of filial piety (hyojung) and resolve the various social issues currently occurring.

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Session 6

**Studies on
Religion and Theology
for Co-Righteousness**

Theology of Religions and its Relevance to Peace

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Abstract: This paper will explore the topic of the theology of religion, an area of theology that considers how one religion understands another religion theologically. Theology of religions explores the way in which the truth claims of other religions are understood in comparison to one's own religion. While all religions---Hinduism, Judaism, Buddhism, Islam, Sikhism, etc.-- may have an explicit, implied or nascent theology of religions, this paper will focus on Christianity and Unificationism/FFWPU, as a religious movement that identifies itself as building upon and fulfilling the Christian foundation. The paper will explore the ways in which Christians, and Unificationists, view, theologically, the doctrines of other religions. It will consider the ways in which theology of religions impacts our relationships with believers of other religions.

Keywords: Theology of Religion; exclusivism; inclusivism; pluralism; christocentrism, theocentrism, soteriology, interreligious dialogue, ecumenism

1. Introduction

Throughout Christian history [1], for example, there have been a variety of approaches to the truth claims of other religions. In recent decades, the field of "theology of religions" has emerged, giving rise to various typologies that attempt to clarify the dominant approaches one religions take in analyzing another religion. For example, one commonly referenced typology, developed by Alan Race in 1983 in his book, *Christians and Religious Pluralism* [2], Race proposes a threefold typology that includes an exclusivist approach, an inclusivist approach and a pluralist approach. The Catholic Jesuit theologian, Paul Knitter, developed an expanded and more nuanced typology consisting of four models or approaches to understanding other religions which he identifies as the replacement model [3], with similarities to Race's exclusivist model; the fulfillment model, with some similarity to the inclusivist model of Race; a mutuality model, which represents Knitter's call for a dialogical approach to other religions; and the acceptance model, where the reality of religious pluralism and a diversity of religious truths is accepted as an inevitability [4]. Theology of religions is particularly relevant to the encounter with other religions in missionary or evangelical contexts [5]. Are other religions and/or their teachings worthy of respect and serious engagement or are they threats or errors to be avoided or challenged? How has theology of religion impacted evangelism, missionary activity, interreligious relations, and, to a larger extent, international relations? Are there some best practices that have evolved that help assure civility, mutual respect and mutual learning processes in the encounter with other religions? Furthermore, I will consider the extent to which Unificationism has succeeded in developing a theology of religions that avoids exclusivist attitudes and practices as applied to evangelism and other forms of engagement with, or encounter with other religions? Has Unificationism developed an approach that encourages mutual respect, dialogue and cooperation among the world's religions, while also affirming its unique truth claims and soteriological convictions? What has the theology of religion to do with peace?

I argue that the theology of religions is directly relevant to peace, such that a well-developed theology of religions contributes to mutually respectful and cooperative relations between and within religions, providing the basis for peaceful relations among religions to emerge, thereby potentially impacting international relations in a constructive way.

2. Materials and Methods

This paper will consider the ongoing development of the theology of religions that has developed in the late modern and contemporary period in the West. Drawing on some 19th century figures such as the German historian of religion, Ernst Troeltsch and, more recent scholars such as Paul Tillich [6], Karl Barth [7], Karl Rahner [8],

John Hick [9], and Raimundo Pannikar, I will discuss the work of leaders in this field such as Alan Race and Paul Knitter, as well as various documents on the topic from the Catholic Church, especially Vatican II's *Nostra Aetate*, and from the World Council of Churches.

3. Discussion

While the general diversity of cultures and civilizations, along with a plurality of religions, has been characteristic of human history, it is also the case that the acceleration of encounters with other faith traditions has intensified in recent decades, particularly since the middle of the 20th century, coinciding with increases in immigration, international travel, global trade and mass communications [10]. The increased awareness of the plurality of worldviews, religious and secular alike, has contributed to a variety of responses from Christianity in the effort to form a comprehensive perspective that takes into account the vastness of other perspectives and points of view when it comes to questions of ultimate truth concerning God and salvation [11].

Whereas in the field of science there are generally agreed upon standards---essentially the scientific method---that can be applied in an effort to determine the status of scientific truth claims, in the field of theology the evaluation of truth claims is more complex. In the case of religion, theological or doctrinal assertions can be made and defended by appeal to authority or by appeal to a logic internal to a particular tradition, but very often lacking the universality that can be obtained in science. Even the universality of theism or the doctrine of God is unsettled. For example, the doctrine of the trinity, formulated during the Council of Nicaea in 325, is not accepted by Judaism, Islam, or Buddhism, and there remain serious disagreements between Catholic and Orthodox Christianity, leaving them divided for 1000 years over the finer aspects of the doctrine of the trinity [12]. These differences are seemingly unresolvable through reliance on rational argument, doctrinal decree, or dialogue; in general, believers simply agree to disagree.

In science, a new theory must be tested, scrutinized and subjected to various efforts to falsify hypotheses, and it is only after an overwhelming consensus has emerged, grounded in sound argument backed by evidence that a theory becomes accepted by the community. It is in this way that science has developed or evolved over time, and scientific knowledge has grown and expanded.

Religion, however, strongly rooted in foundational texts or myths of origin that emerged, in many cases, centuries or millennia in the past, faces greater challenges in terms of reaching consensus when it comes to divergent or competing theories. Empirical verification of religious claims is complex, particularly since religious convictions tend to be rooted more strongly in intuitive, emotional, affective, and social factors [13]. The language of religion or spirituality often includes concepts such as faith, love, obedience, revelation, vision and inerrancy.

Among the major areas of potential disagreement among religions are doctrines or teachings related to the status of the founder of the religion and the requirements for achieving salvation. For Christianity, Jesus is the defining figure, and his teachings, found in the New Testament, are authoritative. For many or most Christians, Judaism and its scriptures are viewed as lacking or failing to comprehend or benefit from the advances represented in the spiritual awakening that Jesus initiated and brought about [14].

Of course, Christianity arose as a sect within or related to Judaism. Eventually, from the 1st to the 4th century, Judaism and Christianity drew lines of distinction and division. Christianity kept Judaism's scriptures, but relegated them to a subordinate status. While some early Christians, Jewish Christians, sought to unify Judaism and Christianity, the dominant trend moved toward separation and even to the identification of each by the other as heretical.

Could this split have been avoided? Was it stimulated by an implicit theology of religions? Could Judaism and Christianity have taken a different path than the one that played out over the past 2000 years? Could Judaism and Christianity have been reconciled, even after the crucifixion of Jesus? Or were their respective theological claims, along with their respective theologies of religion, irreconcilable?

This question is relevant to Unificationists in terms of our relationship with Christianity. How might Unificationism avoid a similar Jewish-Christian bifurcation that is characterized by ongoing estrangement and acrimony. The development of a reasonable theology of religions may be helpful in this regard.

3.1 *New Testament Texts That Offer a Basis for a Theology of Religions*

When we look at the New Testament we find numerous passages related to the theology of religions. For example, even texts related to the three wise men---probably Zoroastrians---are suggestive of a wider or innate human

capacity to receive spiritual insight concerning the coming of Jesus. In other words, God's communication with human beings is not limited to the Jews and the Christians [15].

Jesus himself, in one of his most well-known parables, the good Samaritan, identifies goodness in a man who was not viewed as chosen or versed in orthodox teachings. The Samaritan exemplified the "love of neighbor" and the ethics of Jesus.

Jesus also commended the Roman Centurion whose faith Jesus said was great, even though he had not been introduced to either the Jewish scriptures or Jesus teachings.

In the Sermon on the Mount, Jesus speaks more about ethics than doctrine. In fact, few of Jesus' words are explicitly doctrinal.

While the above passages show a generosity to those who are outside the community, many passages in the New Testament are critical of Judaism, citing it as a religion of law lacking in the gospel of love and grace that Jesus taught and exemplified.

The New Testament is also ambivalent in terms of the narrowness of exclusivity of the path to salvation. Consider the following:

Acts 4:12: Neither is their salvation in any other [than Jesus]: for there is none other name under heaven given among men, whereby we must be saved.

Acts 17:26-28, Paul in Thessalonica: From one man he made all the nations, that they should inhabit the whole earth; and he marked out their times in history and the boundaries of their lands. God did this so that they would seek him and perhaps reach out for him and find him, though he is not far from any one of us. 'For in him we live and move and have our being.' As some of your own poets have said, 'We are his offspring.'

The first passage suggests a narrow path; one that we might describe as both exclusivist and christocentric, while the second opens a broader way, one that we might describe as inclusivist and theocentric, suggesting that God, from the beginning, is guiding all peoples, each one being the offspring of God.

In the field of the theology of religions, Alan Race argues as follows [2]:

The Christian Theology of Religions has come to be the name for that area of Christian studies which aims to give some definition and shape to Christian reflection on the implications of living in a religiously plural world.

According to Velli-Mari Kaikkainen, writing in his Introduction to the Theology of Religions, theology of religions "studies the various religious traditions from the perspective of Christian faith and its foundational affirmation concerning Jesus Christ [16]."

One of the first articulations of a typology of theologies of religions was formulated by Alan Race in his book, *Race, Alan (1982). Christians and Religious Pluralism: Patterns in the Christian Theology of Religions.* Maryknoll, NY: Orbis Books. Race identified three core approaches to theology of religions, the exclusivist, the pluralist and the inclusivist.

The exclusivist model maintains that salvation only comes through explicit faith in Jesus Christ, leaving no other effective path to salvation outside of belief in Jesus. Swiss theologian Karl Barth may be identified as an advocate of exclusivism, as are Christians known as fundamentalists [7]. Associated with the exclusivist perspective is the expression *extra ecclesiam nulla salus*, meaning "outside the church there is no salvation", a saying attributed to Cyprian of Carthage, dating back to the 3rd century. Barth's theology of religions may also be described as Christocentric and ecclesiocentric.

The pluralist approach, holds that God seeks the salvation of all humanity and that many paths may lead to the same destination. A major advocate of pluralism is the theologian John Hick [9]. Hick, a Christian, but one informed by a Kantian theory of knowledge that limits the human capacity to know ultimate realities beyond the realm of appearance, does not hold that Christianity can be claimed as the exclusive path to salvation. Rather, he maintains, a loving God has opened many doors to ultimate salvation, desiring that all people find their path to salvation [8]. Hick developed a metaphorical Christology, discounting claims that Jesus was God or the son of God except in a metaphorical sense of Jesus' closeness to God. As such there are a plurality of ways to salvation, and Christian claims to absoluteness should be avoided.

The inclusivist approach has some similarity to pluralism but differs in that it affirms the centrality of Jesus for salvation, but maintains at the same time, that God has opened other paths that lead, at least in part, to salvation, even though the believer may not have any knowledge of Jesus precise teachings. Karl Rahner is often associated with the inclusivist view, advocating the concept of the "anonymous Christian" to indicate that persons could be "Christian" even without knowing Christian theology [8]. Above all, God desires that all men and women be saved, and offers opportunities for that to happen. Rahner's view is more theocentric.

Another typology of the theology of religions has been developed by Paul Knitter [3]. Knitter's typology includes four models, the replacement model, with similarities to the exclusivist model mentioned above, the fulfillment model, which emerged out of Vatican II and the theology of Karl Rahner, the mutuality model that speaks of "many true religions called to dialogue", and the acceptance model, wherein the multiplicity of religious paths and truth claims are not resolved into a single truth, leaving us merely to accept this pluralistic reality [8].

While theology of religions applies largely to Christianity's views of other religions, it may also have some application to the relations among the diverse strands of Christianity, which at times may seem to be as plural and disparate as are the relations among the world's religions vis a vis Christianity [17]. While a religion may appear monolithic when observed from a distance, in reality, closer inspection reveals an intrareligious diversity and pluralism, not only among denominations but also within a single sect or denomination [18].

Concepts of heresy and excommunication have been part of Christian history, dating back to the earliest days of the emerging Christian religion, which experienced a plethora of "denominations", including Arianism, Nestorianism, Monarchianism, Gnosticism, Donatism, Pelagianism. This reality continued through periods such as the Protestant Reformation as it diverged theologically from the Roman Catholic Church. The 19th and 20th century continued to give birth to innovative expressions of Christianity were not always welcomed, including 7th Day Adventists, Jehovah's Witnesses, Latter Day Saints, and the Unification Church, or Family Federation for World Peace and Unification.

Thus, there has been a history of pluralism within Christianity itself, leading painfully yet eventually to a growing tolerance and a generosity of spirit toward divergent paths. Some, however, view such generosity as an unacceptable compromise that only weakens the faithful and weakens the church, by giving credence to falsehoods and distortions of essential truths.

As a new religion that identifies itself as within the genealogy of Christian history, originating in Korea, the Unification Church, now Family Federation, has developed a new set of doctrinal claims related to the doctrine of God, Christology, ecclesiology and soteriology [19].

3.2 Unification Theology of Religions

As an expression of Christianity that emerged in the age of radical pluralism, FF has some of the features of Christianity's ambiguity toward other religions, manifesting both inclusivist and exclusivist characteristics.

When we examine Unificationist Christology we observe an appreciation of the doctrine of the Trinity, yet one that reinterprets that doctrine in accordance with the dual characteristics of God as both masculine and feminine, giving rise to a doctrine of God that affirms monotheism while also affirming two persons or aspects of God; one as Father and the other as Mother. In addition, as Jesus was described in various ways, such as "son of man" or "second Adam" or "only begotten", within FF, Hak Ja Han Moon and Sun Myung Moon are understood theologically as True Parents, with Mother Moon standing in the position comparable to Jesus, as only begotten daughter, and Father Moon as the messiah of the 2nd coming, called to carry on and fulfill the mission of Jesus. Together, their marriage represents the Marriage Supper of the Lamb foretold by the New Testament. Through their wedding, they establish the position of True Parents, itself a new Christological concept, one which represents the goal that should have been fulfilled at the time of Jesus.

Despite the exclusivist claims of Unificationist Christology, Unificationism represents what Race would call an inclusivist theology of religions and Knitter a fulfillment theology of religions. I cite the following reasons:

Like Jesus, Mother Moon and Father Moon were entirely comfortable with believers from all faith backgrounds. Of course they are also entirely comfortable affirming their own theological status, yet not in an absolutist or ungenerous way. Mother Moon in particular asserts her unique christological status as only begotten daughter, but continues to dialogue with and collaborate with other believers in a mutually respectful way.

At the same time, along with her hospitality and generosity toward what might be called "anonymous Unificationists"---often described by Mother Moon as "prepared people"--- she has developed an ecclesiology that is quite open, evidence in her moving from a more Christocentric church to a more theocentric "community" known as "Heavenly Parent's Holy Community (HPHC)." The HPHC is a more open community that may include those from diverse religious backgrounds.

Like Father Moon, Mother Moon has also been a strong advocate and supporter of interreligious dialogue, viewing it as an essential component of the effort to establish the Kingdom of God, and cheonilguk. Many initiatives were founded and supported over decades by Mother and Father Moon, including more recently the Universal Peace Federation and its Interreligious Association for Peace and Development. Additionally, the Moon's

have worked to promote greater collaboration between religions and governments, encouraging more of a “soft power” approach to peace, along with faith-based diplomacy that complements conventional diplomacy. This vision was advocated as essential for a renewed United Nations, namely, the development of a UN charter and framework that included a place at the table for religious leaders, along with member states and NGOs affiliated with ECOSOC [20].

The linkage I have outlined above, shows the connection between theology of religion, interreligious dialogue, interreligious cooperation, interreligious peace, and peaceful international relations [21]. In order for this logic to unfold, a more inclusivist theology of religions is required, coupled with a recognition of religions wider relevance and indeed its responsibility as agent of transformation, as an agent of public leadership for a world in need.

In 2020 Mother Moon also make a dramatic shift in the flagship institution of higher education in America, namely the Unification Theological Seminary. She advised that UTS shift its focus, moving from being a “seminary”, which implies a more denominational focus to be a graduate school which has a broader range. With this in mind UTS was changed from being a seminary to HJ International Graduate School for Peace and Public Leadership [22].

The shift to Peace and Public Leadership represents, in my view, an implicit theology of religions, calling for harmony among religions coupled with a vision for the engagement of religion with wider world affairs, including international relations, political economy, United Nations affairs, the environmental movement, and preventive peacebuilding.

The Unificationist theology of religions has an innovative christocentrism, ecclesiocentrism and theocentrism, tempered by a doctrine of God as ultimately parental, seeking the wellbeing of all people, as a font of universal grace. In this way, the particularism of religion is balanced, enhanced and complemented by the universalism, avoiding the polarization represented by both exclusivism and pluralism [23].

4. Conclusion

“Real brotherhood and sisterhood cannot be achieved without God and the ideal of universal true parents.” Hak Ja Han, Assembly 2000 at the United Nations

“I submit that serious consideration should be given to forming a religious assembly, or council of religious representatives within the structure of the United Nations.” Sun Myung Moon, Assembly 2000 at the United Nations [24].

“No world peace without peace among religions, no peace among religions without dialogue between the religions, and no dialogue between the religions without accurate knowledge of one another.” Hans Kung

Hans Kung was a pioneer in the theology of religions, ecumenical dialogue, and interreligious dialogue [25]. Kung, a Roman Catholic theologian. Kung challenged aspects of his church’s tradition and faced opposition. His ideas and efforts bore fruit and gained widespread support particularly observed at the time of the 1993 Parliament of the World’s Religions in Chicago where he introduced his quest for a global ethics rooted in shared values of the world’s religions.

Rev. Sun Myung Moon and Dr. Hak Ja Han Moon introduced their interreligious vision upon moving to the United States in 1972, forming a seminary in New York with an ecumenical and interfaith faculty, and, on the foundation developing a variety of ecumenical and interreligious initiatives such as the Global Congress of the World’s Religions, the New Ecumenical Research Association, the Youth Seminar on World Religions, the International Religious Foundation, the Council for World Religions and the Assembly of the World’s Religions, drawing attention of theologians and scholars of religion from across the world.

In the year 2000, one year after the founding of the Interreligious and International Federation for World Peace (1999), Rev. and Mrs. Moon spoke at the United Nations advocating an integration of spiritual engagement and interreligious activism within the UN system, for the sake of world peace [26].

Father and Mother Moon founded a new religious movement that affirmed not only Judaism and Christianity, as its “elder brothers”, but the world’s religions as siblings in the providence of God, the Heavenly Parent. In our world today, a global religious awakening is needed. However, not an awakening that advocates extremism or exclusivism, but one that is inclusivist, collegial and cooperative. Religions in dialogue and cooperation will learn from each other and, at the same time, the values and best practices of the religions will begin to impact the

political and economic and social spheres. Theology of religions can therefore be a significant factor in promoting peace and public leadership that benefits humanity.

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What is the Role of Unificationism in Addressing the Comfort Women Issue?

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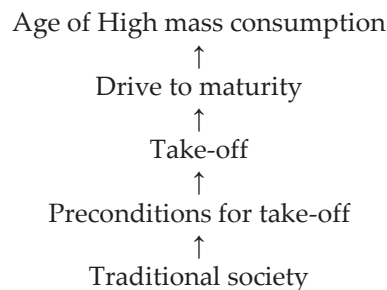
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Abstract: Since 1991 when Kim Hak-Sun became the first woman to come forward to the public, identifying herself as a victim of the World War II Japanese Imperial Army's Comfort Women system, a sharp divide has existed between Japan and many of its neighbors, with the divide between Korea and Japan being the sharpest and the most publicized. Japan, throughout the 1990s and the first decade of the new Millennium, attempted to dismiss this issue. The Japanese court system, beginning with December 6, 1991 Association of Korean Victims Lawsuit in Tokyo District Court consistently sided with the Japanese government's official position that an unconditional acceptance of responsibility for this tragic chapter of history by Japan and the provision of reparations by Japan to the system's victims was not required as the plaintiffs had argued. Japan's interest in addressing this matter was piqued, however, when the first Memorial to commemorate the Comfort Women was established in Palisades Park, New Jersey, United States of America in 2010 followed by the first memorial in Korea directly in front of the Japanese Embassy in Seoul in 2011. This presentation proposes to re-examine the Comfort Women issue, considering its scope and significance, even providentially, and invites reflection and consideration of how progress can be made in the resolution of this problem. This presentation also invites consideration of True Parents' view of this tragedy and assesses the role that they and FFWPUI have already played and might play in the future in the transformation and attenuation of this conflict, utilizing a Unificationist application of Peace Studies to this problem in particular.

Keywords: Unificationism, Comfort women issue, World war II, Japanese court, Korean victims

1. Introduction

Many years ago, I was invited to speak at a Unification Thought Seminar that took place in Tokyo. I still remember that seminar as well today as if it had happened just last week. In my years as a Professor and even prior to that in my time as a Banker, I had learned about the various levels of socioeconomic development as explained by Walt Rostow in his book *The Stages of Economic Growth: A Non-Communist Manifesto* [1]. Rostow outlines the various levels of development that societies pass through and he breaks it down as follows:



Rostow assigns specific characteristics to each of the enumerated stages:

At some point as I continued my talk, I discussed the respective stages of the Take Off and the Drive to Maturity, noting that in those stages there is the need to develop a skilled workforce and also the establishment of specific foci within the manufacturing field.

I made the comment that the period of Japanese occupation contributed to the building of a skilled workforce and opined that at least in that sense, the Japanese, during their occupation of Japan, had assisted the Koreans in accelerating the development of their economy. One of the Korean participants in the program had a very adverse

reaction to this and, for me, it was an initiation to the extent to which strong animosity existed towards Japan on the part of certain Koreans, including our members. Perhaps there is no area where that animosity exists at higher level than when it is seen from the viewpoint of the still unsettled Comfort Women controversy. Granted unlike the previous Moon Jae-in government, the current government is less inclined to have this matter brought to the forefront as was the case in the past. Nevertheless, the problems remain and it probably will take nothing more than a change in government towards the direction of the previous government for the problem to reappear in Korea.

2. Discussion

2.1 *The Position of Rev. Sun Myung Moon on the Reality and Significance of the Comfort Women System*

In Japan, the spirit of denialism remains a strong force. While some denialists recognize that Korean women joined the Comfort Stations, they stress that they did so as volunteers and furthermore that they were well paid. For his part, Father Sun Myung Moon took a clear view on the reality of the World War II Comfort Women System, referring to it as “sexual slavery” and judging it to have served a demonic purpose:

How did Japan dominate Korea for forty years? Even the satanic side knew that in the future Adam on the heavenly side would appear. Satan already knew of the coming of the true Lord; he knew the coming of the Lord as the culmination of four thousand years of history. Therefore, Japan occupied Korea in order to destroy that possibility. That is why Japan invaded Asia. From this point of view, we can understand that Korea is a providential nation centered on God's will. We know that it is a principle of development that prior to the appearance of what is true, what is false appears. That is why the devil invaded Asia and ruled it for forty years.

Thus, the satanic forces brought Korean women aged from twelve to forty, whose purity was most cherished, into sexual slavery with the intention of staining the national character of the Korean people [2].

2.2 *Democracy at Risk*

Unificationists recognize that democracy emerged as a force through which humankind can be able to freely practice their faith, experience the presence of God, and likewise have a clear voice in the future political, economic, moral and cultural direction of the world. While recognizing the important progress that has been made in China in recent decades, they also observe that China is not committed to democracy as it is outlined in the constitutions of the Republic of Korea, Japan, and the United States. As China becomes an increasingly important political, economic, and military power, we can recognize that it can pose a threat to democracy and a threat to civil society and civil society organizations, including Churches, in nations which do not embrace the political and social views of the communist world.

In his writings on the Governance of China, President Xi Jinping has made clear that at the core of his worldview is an alliance with the central values of the Communist Party and its worldview. That worldview and its proponents hold a privileged position in Chinese society and opposition to it can result in marginalization and, should opposition or resistance be viewed as excessive, it can also lead to reprisals, as witnessed in the cases of China's Uyghurs, the overly ardent supports of the Dalai Lama in Tibet, and the pro-democracy youth movement in the case of Hong Kong to cite a few examples.

Unificationists hold the view that Korea plays a central role in the political and social developments in today's world and that Korea can be considered to play a role comparable to the role played by Israel at the time of Jesus' appearance more than 2000 years ago. Democracy was developed we understand through Divine Principle and Unification Thought to serve as a protection against the eventuality of what prevented Jesus from fulfilling his Providential Role 2000 years ago as God's only begotten son.

The United Nations heralds in the Preamble to the Universal Declaration of Human Rights' “freedom of speech and belief and freedom from fear and want” as “the highest aspiration” and where “human rights should be protected by the rule of law” [3]. Yet these were not in place in Jesus' time nor where they in place in China and in Pyongyang following the communist takeover of those lands following World War II.

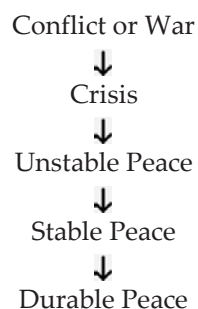
The role of the United States and the role of Korea’s regional neighbors, particularly Japan, Taiwan, and the Philippines are of central importance to protect and foster the climate that allows Korea’s to fulfill its calling before God and the “huddled human masses yearning to be free” [4].

Those familiar with the teachings and views of the Unification Movement understand that particular importance has been repeatedly attributed to the relationship amongst Korea, Japan, and the United States. For more than three decades, a divide has existed between Korea and Japan over the so-called “comfort women issue” and in spite of efforts by Japan to own up to its responsibility, after repeated denying accountability in the past, Koreans question the sincerity of Japan’s apologies and acceptance of responsibility and the Japanese themselves, as seen openly by denialists and more discreetly by other skeptics, question the extent to which they should indeed be held accountable and suggesting that the Comfort Women issue only scratches the surface of what can indeed be viewed as a hatred of Japan while Koreans retort that Japan fails to show respect for Koreans, for Korean tradition, for Korean history, and for the injuries imposed on Korea by Japan’s defilement of its traditions, its history, and its people, with the tongue-in-cheek apologies and regrets expressed stemming more from the desire to “save face” than to reckon with wrongs that could have been avoided.

Unificationism’s understanding of the central role that Korea needs to play in addressing the world’s problems and rectifying the direction that our world is taking, including the direction currently being taken by Japan, the United States, and the People’s Republic of China, should spur it on to want to find a way in which to address this problem and it is in that spirit that I write what follows here.

2.3 From War to Durable Peace

In Conflict Resolution and Transformation, Lund’s curve [5] plays a valuable role in assessing the level and intensity of the conflict in any and all cases. Relationships between nations (or between any parties if we wish to extend it further) fit into one of the five following categories:



In the case of a Durable Peace, it is almost impossible to break bonds between two nations, there is a compilation of experiences and perhaps even shared cultural and religious ties that make the breaking of ties quite challenging. Peace specialists often point to the case of the relationship that exists between Canada and the United States, two countries that share a border of 8,891 Kilometers, a common language, a common culture, common religious heritages, and shared histories. While briefly at war with each other some two centuries ago, that chapter has long disappeared into the past of these countries.

2.4 Lessons for Korea and Japan from France and Germany

Perhaps of more interest and of greater relevance to our topic today is the transformation in relations that has occurred between France and Germany that arguably also today enjoy relations that can be compared to those of Canada and the United States, a relationship which through the evolution of developments resulting to a significant extent from the regional political and economic collaboration that has led to the creation of the European Union, an entity which, through its Treaty of Lisbon, has progressed to a point where the laws and regulations of the EU serve as the ultimate measure of jurisprudence and economic and defense policy for the member nations, including France and Germany.

One observes that there is not an equivalent of a European Union in Asia, although Dr. Hak Ja Han Moon has advocated for this [6]. The absence of such a regional union helps to explain why relations between Japan and Korea or relations between Japan and China are where they are at the present time.

While there is truth to this observation, it alone does not sufficiently explain the process needed for a change in Korea-Japan relations. Within the case of France and Germany, recognition of the role played by French collaborators in the Nazi control of Vichy France was key to addressing the deep divide between France and Germany. In Albert Camus' well known soul-searching novel *The Fall* [7], the protagonist Jean-Baptiste Clamance deals with guilt and his failure to act in at a moment when his taking a risk could have potentially saved a life. While Camus' text has a variety of meanings and messages, its fundamental thesis, particularly, given that it was written only a little more than a decade after the end of World War II, invites reflection on events such as the Holocaust and the decision by German, Dutch, Italian, and French citizens to stand by and do nothing rather than oppose the senseless isolations and destruction of innocents, even children, simply because of their ethnic origins and the call for their extermination by Hitler.

Following the War's end, many French citizens could no longer engage in a cover-up. Over time it was no longer acceptable to point only at the Germans but to admit that they too had enabled despotism and genocide by their silence while engaging in commerce and finding ways to prosper within the Nazi-backed Vichy Government, even serving the needs of Gestapo officers intent on bringing to fruition the vision of Hitler, a megalomaniac and an agent of evil, going so far as to identify friends, former classmates, and neighbors of Jewish ethnicity who would then be detained and, soon forced to board stockcars leading them to Auschwitz, Buchenwald, or Dachau. Like the principal character of Camus' *The Fall*, a critical mass of France's citizens came to recognize that "Tout le monde est coupable," i.e., "Everyone is guilty."

The accounts of Korea's comfort women reveal over and over again that those who rounded up innocent Korean women and girls, as young as twelve and thirteen, were not just Japanese military but, in so, so many cases, they were Koreans paid by the Japanese. Also, it was not just Japanese soldiers who inflicted atrocities upon civilian populations, upon captured foreign military in spite of the protections assured by the Geneva Convention. It was members of the Japanese soldiers of Korean ethnicity who also numbered among the actors. Korea expert Michael Breen has written of British soldiers who were tortured and executed by Korean soldiers in the Japanese military and challenged the 2006 pardon by the Korean Government of 83 Koreans guilty of war crimes while part of the Japanese military:

"People who committed crimes against humanity are not innocent by virtue of being Korean any more than Japanese who brutalized Koreans are innocent by virtue of being Japanese" [8].

When I first studied the emergence of the Korean Council for the Women drafted for Military Sexual Slavery by Japan and particularly the lives of the women who suffered because of it, I was surprised that it traced its founding back to Ewha Women's University, an elite Korean women's university, which to survive during the occupation made numerous concessions to Japan that enabled it to do so. Almost none of the Koreans brought into the system were of the social class origins of Ewha University students. The Council was criticized in recent years when its leader Yoon Mi Hyang was accused a parlaying her role in the Council into a seat as a Korean leader and of embezzlement of funds.

There are those who have written on how the Comfort Women movement rather than being a vehicle to empower women has been a tool for nationalist and populist activity that has done little to improve the status of women. In 2020 Lee Young Soo, a former comfort woman and an activist in the movement, called out the weekly demonstrating in front of the Japanese Embassy in Seoul, saying that "the rallies only teach young students hatred" and "adding that young generations of South Koreans and Japanese should interact more and become friendly to each other" [9].

In an article which appeared in the *New York Times* in April 2023, Korean journalist Se-Woong Koo described the lamentable animosity that exists towards Japan. He calls for healing, for the need of recognition of the commonalities shared by Korea and Japan as modern democracies, threatened by an authoritarian China with arguably expansionist intentions. Koo ends his article by quoting from his own mother following a recent visit to Japan:

I took my mother to Japan last month to see the cherry blossoms in bloom. Post-pandemic travel between the two countries has surged, and Korean tourists were everywhere. As we

strolled along the Sumida River in Tokyo, its banks ablaze with the soft pink of cherry blossoms, she let out a contented sigh, turned to me and said, "This country is so beautiful and civilized" [10].

2.5 How does one heal the Problems between Korea and Japan?

The strategic challenges of Korea and Japan may not be solved by these countries and certainly not without the support and insights of organizations such as the Universal Peace Federation. At its founding the Korean Council carefully landscaped the battlefield. They chose to focus on the Japan role in the Comfort Women system and not to deal with other related issues such as the use of the Comfort Women stations by US soldiers following the end of World War II from August 1945 to March 1946, the establishment of shanty villages around US Military bases in Korea and in Japan where for decades, indeed for a longer period than the existence of the Japan Comfort Station system, Korean women were taken advantage of by US Military Servicemen and treated in a demeaning fashion. Their goal was Japan first and America later.

Americans have been blindly deceived into setting up Comfort Women Statues in fifteen towns in the United States including cities such as Glendale, California where fifth and sixth generation Japanese-Americans whose descendants, born in the United States, were living there at the time of the December 1941 attack on Pearl Harbor by Japan. While there is no statue in Glendale or anywhere else in America which demeans white Americans for the enslavement of black Americans, there is a statue in Glendale specifically highlighting the wrongdoings of Japan rather than the suffering of the victims. It is laudable to honor the victims of the comfort women system; however, it is wrong to demean a nation and a people and allow them consciously or not to be associated with a system that they had nothing to do with.

The Holocaust Museum in Washington, D.C. brings to life the suffering that the Jewish people endured. It does not teach those who visit to hate Germans. It laments the inhumanity that allowed a government, an ideology, and an institution that, for over a decade, taught people to hate and to exterminate Jews. The Comfort Women statues in the United States and the network that has emerged from it has served to justify hate for today's Japan and those of Japanese heritage rather than lament the victims of the cruel Japanese militarism that enabled these things to happen.

3. Conclusions

Americans need to come forward and, rather than local governments supporting the creation of monuments, which denounce Japan for its crimes against the victims of the comfort women system, such monuments should also recognize their own role in the demeaning of Korean and Japanese women by the American Military through the prostitution system patronized by American military for eight decades in Korea, Japan, and the Philippines. Koreans need to come forward and recognize that no President or Committee can pardon Korean collaborators for their role in the Japanese occupation, as was done. Koreans need to recognize that Koreans played an important role in the establishment of this horrible comfort women system by assisting in the deceptive recruiting and cruel management of the system.

Japan must stop hiding and justifying its past wrongdoings. Perhaps, with the help of Americans and Koreans, who have found within themselves the largesse to recognize their guilt, Japan can also be motivated to take responsibility and bring this era to closure.

Today one million Tibetan children are separated from their parents because China wants the sinicized. At least one million Uyghurs live in concentration camps. China saber rattles for control of Taiwan, the Scarborough Shoal near the Philippines and the Senkaku Islands. While, for now, China has no "dispute" with the Republic of Korea over Leodo. But who knows what the future brings? Deng Xiaoping said that the grandchildren of Japan and China could address issues such as territorial claims on the Senkaku Islands. But the "children," not the "grandchildren" of Deng have become the activists in that dispute.

If within the Unification Movement first, consensus can be reached for a narrative that contributes to regional peace and reconciliation rather than empowering selfish nationalisms and defensiveness on all sides, the Pacific Era and the Asia Pacific Union may indeed find its way to a needed "Jump Start."

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Unifying Religions, as Well as Science and Religion, by Understanding the Four-Position-Foundation

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Abstract: What is a symbol of the Four-Position-Foundation? Are there different ways to represent the Four-Position-Foundation? This study presents some major symbols of Judaism, Hinduism, Taoism, Buddhism, Christianity, Islam and Unification Thought as very similar expressions of the Four-Position-Foundation. Although they are somewhat different in their focus, the most common features of the Four-Position-Foundation are shown to be present, allowing us to have a common denominator or language for sharing experiences across cultures. Atheists sometimes wonder, "If there is a God, then why are the major religions so different." This study shows that they are not so different, due to the common dynamic of the Four-Position-Foundation present in their most holy symbols and descriptions of ultimate reality. Finally, a hypothesis is made linking the Four-Position-Foundation to an Internal Periodic Table, that if true, helps unify science and religion, possibly resulting in reduced time and expense for developing materials with special properties.

Keywords: Unification of Religions, Science and Religion, Four-Position-Foundation, Internal Periodic Table

1. Introduction

To look for the common denominator of the four-position-foundation in religions, let us investigate inter-religious mysticism. To accomplish this, we need to know people's experiences; we need to read their sacred books, if they are available, and talk to them with an open mind. We must be ready to learn their languages, terms and symbols. What did they experience? How are they expressing their experience? Can I relate to that through having had similar experiences? Do they have a method of teaching other people how to experience the same thing and thus carry on their tradition? The major religions of Judaism, Hinduism, Taoism, Buddhism, Christianity and Islam all began and continued with experiences that they were able to talk or write about and to share successfully. Science also began with experiences and developed a system to share them successfully. Recall that the first step in the scientific method is observation. Experiences are the observations of religious and mystical traditions. To the degree that a religion is true, it is also logical, orderly, experienceable, observable, repeatable, principled, real and thus scientific.

Rev. Sun Myung Moon probably was the first person to use the term "four-position-foundation." He used it, for example to describe mind/body unity and often asked his audience, "Have you united your mind and body?" What are the mind and the body? Are they two aspects of the same thing? Is there a psychological aspect of matter. Is this question related to the wave/particle duality of quantum mechanics, or to the equivalence of energy and matter of Einstein's $E = mc^2$? These are important questions that both science and religion have proposed answers to in various Big TOEs (Theories of Everything – world views) arising from experiences and observations. There is a lot of work remaining to be done to clarify the relationship between the mind and the body, which represent the spirit world and the physical world, also known as heaven and earth. This study juxtaposes diagrams with necessarily brief explanations from the above-mentioned religious traditions.

Rev. Moon speaks here with characteristic determination from his world view about the need to "observe and digest" in order to unify:

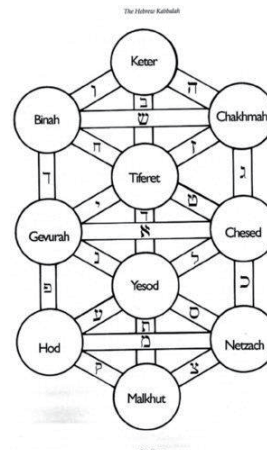
"We must know clearly that it is our mission to unify; before we can do so we must observe and digest. This is reasonable, like all the laws of creation; it applies on every level of family, society, nation and world . . . There is nothing else I can teach you; there are a limited number of important principles. This is a simple principle, but it applies to every level and in applying it you will do your mission." (The Way of Prosperity and Defeat, March 11, 1979, Belvedere, Tarrytown, NY)

Let us observe and digest in order to unify.

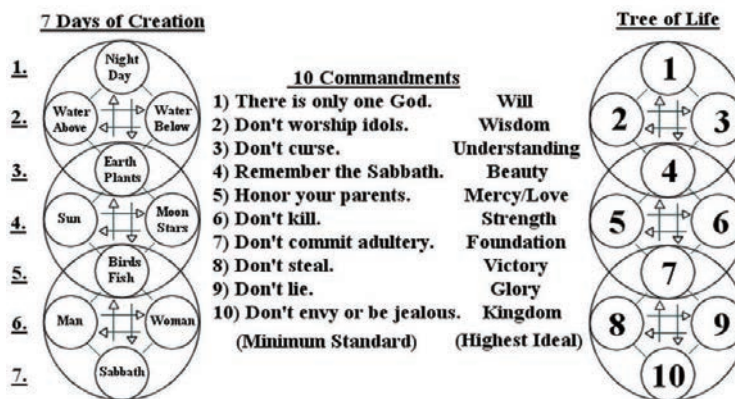
2. Materials and Discussions

2.1. Judaism’s Tree of Life is an alternative representation of the 3-stage development of the four-position-foundation.

There are various versions of the Jewish Tree of Life of Kabbalah, which is the oral tradition of Judaism. The Tree represented here was preferred by the Gaon of Vilna who was the greatest rabbi in 600 years and so was given the title Gaon, meaning “genius.” The Tree of Life in Judaism represents a pursuit of righteous happiness, as indicated by Proverbs 11:30 “The fruit of the righteous is a tree of life . . .” And Proverbs 13:12 “A hope deferred makes the heart sick, but a desire fulfilled is a Tree of Life.”



The Tree of Life represents three levels of soul, namely, the neshamah (divine soul), the ruach (eternal soul) and the nefesh (the level of soul that is in the blood). These correspond quite well to love, life and lineage of Rev. Moon’s diagram (discussed in section VIII) May 1, 1998 (44th anniversary of HSA-UWC, Belvedere, Tarrytown, NY) The ten commandments, the seven days of creation and the 22 letters of the Hebrew alphabet all map to this graphic symbol. The three horizontal lines are the three mother letters: the mem, the aleph and the shin, which represent water, air and fire, respectively, and as well, circumcision of the flesh (the sign of the covenant between God and Abraham), circumcision of the heart, and circumcision of the tongue. Recall James 3:6 “The tongue is a flame.” The three bigger circles in the diagrams below are there to show the process that the output of stage one becomes the input to stage two, and similarly, the output of stage two becomes the input to stage three. The tenth position then returns a result to the origin in position one, completing a circle.

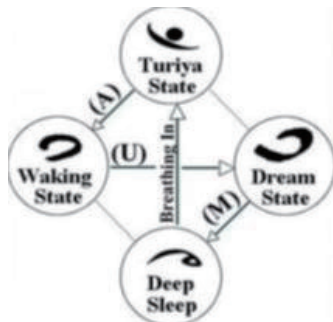


2.1. The AUM (OM) of Hinduism maps to the four-position-foundation and to Judaism’s Tree of Life.

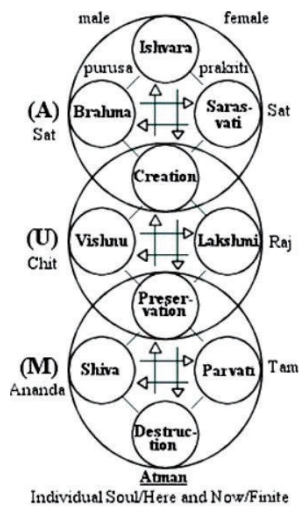


The AUM of Hinduism is explained as a theory of everything in the Mandukya Upanishad, the shortest of the Upanishads with only 12 verses on a single page. The first verse announces itself with excitement to share an important truth:

“OM. This eternal Word is all: what was, what is and what shall be, and what beyond is in eternity. All is OM.”

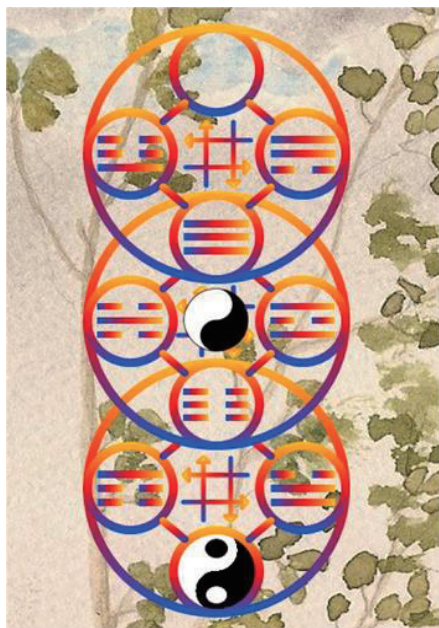


The written symbol for AUM (OM) and the sound itself represent the 4 states of consciousness and the process of breathing in and breathing out. The A is the waking state; the U is the dream state; the M is the deep sleep with no dreams; the silence while breathing in represents returning to one body with God in the transcendent state of consciousness, transcending time and space. The 4 states map to the 4 positions of the four-position-foundation as well as to its expansion in the Hindu Natural Array Tree of Life structure. The top of the feminine column is Sarasvati, goddess of understanding, which corresponds in the Jewish Tree of Life to Binah at the top of the fire column representing the feminine aspect of fire, that led the Israelites through the desert at night. Binah means understanding.



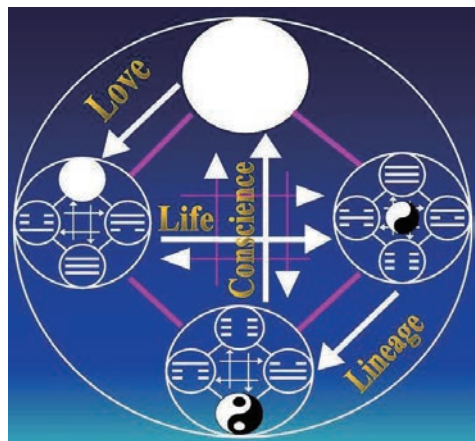
The top of the feminine column is Sarasvati, goddess of understanding, which corresponds in the Jewish Tree of Life to Binah at the top of the fire column representing the feminine aspect of fire, that led the Israelites through the desert at night. Binah means understanding.

2.2. Taoism's wu chi, wang chi, tai chi (variations of terms exist) and cosmic family of 8 trigrams map to the Tree of Life.

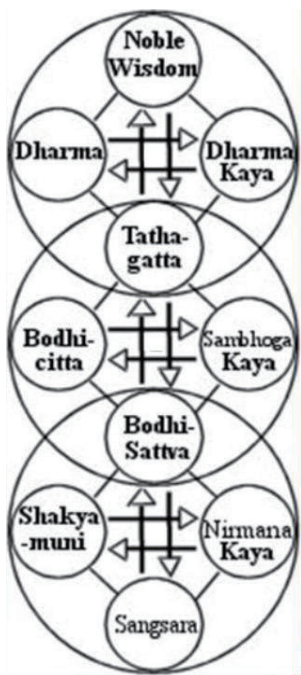


Wu-chi is nothingness, void or emptiness. It represents the origin stage of the four-position-foundation that is beyond time and space. Next the ying and yang symbol which together are the way, can represent the division stage of the four-position-foundation. The union stage is the symbol of the ying and yang with two dots added, representing old yang and old yin, followed by the children who are the young yang and young yin. The eight trigrams are the cosmic family of the father and mother with three sons and three daughters.

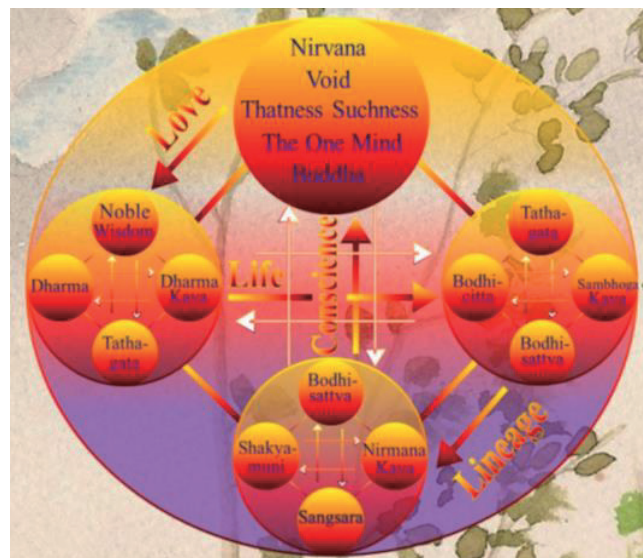
It is interesting that the middle section of this Taoist Tree has the same contents as the Taegukgi, the flag of South Korea. It is also interesting that it corresponds very closely to the middle section of the Jewish Tree of Life which has the masculine water column and the feminine fire column on either side with the parents in the middle column. The middle son of the Taoist Tree also represents water and the middle daughter also represents fire. How did that happen that it matches the Jewish Tree to a certain extent? It could be because the same root source inspired both as slightly different expressions of the dynamics of the four-position-foundation.



2.3. The Tri-kaya concept of Mahayana Buddhism maps to the Tree of Life.



Buddha skipped the Judeo/Christian God experienced by Moses and Jesus and went to the root of God, which is the identity maintaining four-position-foundation centered on heart. Rev. Moon characterizes it as the highest realm of heart that never develops or changes, because it is already the highest. After his enlightenment, Buddha asked people to refer to him as the Tathagata, or “the passed away one.”



The three aspects of body (kaya) have corresponding internal aspects. The Dharma has the Dharma Kaya; the Bodhicitta is the mind of the Bodhisattva who remains behind to save all sentient beings. The Sambhoga Kaya is the body of the Bodhisattva. The physical body of Shakyamuni Buddha is the Nirmana Kaya. The colorful picture to the right adds the lines for Love, Life, Lineage and Conscience suggested by Rev. Moon’s diagram discussed in section VIII.

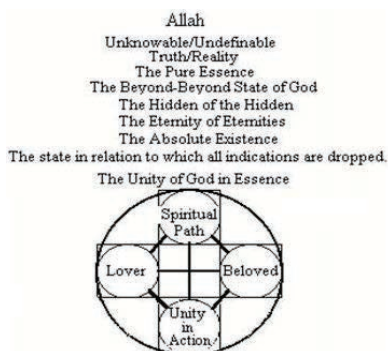
2.4. Statements of Jesus and the Tree of Life



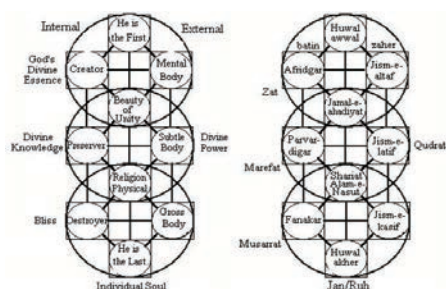
Jesus said in Matthew 6:33 in the Sermon on the Mount, “Seek first God’s kingdom and His righteousness and all these will be added to you as well.” God’s kingdom and His righteousness refer to the lower two holy emanations in the Jewish Tree of Life in the middle column. Specifically, righteousness represents “the foundation of the world” (yesod olam). It is represented by Joseph (the son of Jacob) who refused to commit adultery with Potiphar’s wife and consequently was thrown into prison. This is the number seven position from the top and thus represents the 7th Commandment, “Don’t commit adultery.” Gerschom Scholem explained that this is the oldest and most natural numbering of this holy emanation (Sephira).

In John 14:6 Jesus said, “I am the Way, the Truth and the Life; no one comes to the Father but by me.” Mary Baker Eddy, founder of Christian Science in her book, Science and Health with Key to the Scriptures explains that the Way is Love and that God’s nature consists of Love, Truth and Life. In agreement with Mary Baker Eddy, Rev. Moon also explained that the Way is Love, then put Life and Truth. In this order, he explained that Love, Life and Truth represent the Holy Trinity of the Father, the Son and the Holy Spirit; Love, Life and Truth always travel together like three perpendicular lines, forming the basic structure of existence, again in basic agreement with Mary Baker Eddy. In John 14:6 Jesus explained to Thomas that he needed to continue to connect to Jesus, even after Jesus departed, because Jesus was on the Way to God’s kingdom and His righteousness, and one day, he, Jesus, would return in pursuit of them. The words of Jesus represent the pursuit of the family of God and the kingdom of God through the process of the four-position-foundation.

2.5. Meher Baba's expression of Sufi Islam in his major work "God Speaks" maps to the Tree of Life.

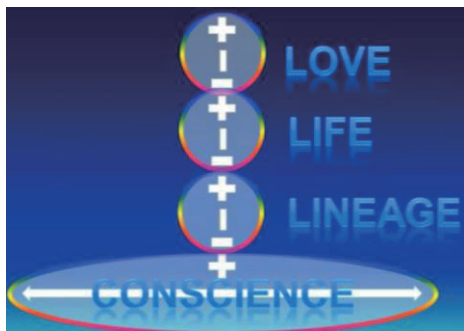


Meher Baba was a world religious figure whose teaching was also for the purpose of unifying religions. He is a representative of Sufi Islam. He had deep mystical experiences and realized similarly to Rev. Moon, that before God created, he was growing up. God asked the question, "Who am I?" and after 7 stages of development he answered his own question by saying, "I am God." The terms in this Sufi four-position-foundation and Tree of Life were taken from his book, "God Speaks,"



in which he drew many charts and diagrams. The Om Point figures into his explanation as the Creation Point, similar to the Christian Logos.

2.6. Rev. Moon's Love/Life/Lineage/Conscience diagram maps to the Tree of Life.

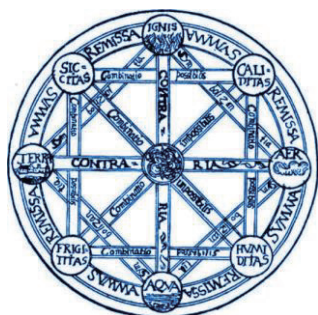


On May 1, 1998 at the 44th anniversary of the Holy Spirit Association for the Unification of World Christianity, Rev. Moon drew the following diagram, which I have styled for the purpose of clarifying the process that he was explaining. He first drew a + sign at the top middle of the blackboard. He indicated that the + attracts a - and they unite forming the next lower down output of another +, which attracts a -, they unite and form a 3rd + and then a 4th +, like three vertical extension cords plugged into each other. Then he drew a horizontal line underneath. The first word he wrote was "Conscience." Then he moved his left hand along the horizontal line of Conscience and explained that

"When God first began to create, He poured out his energy along the horizontal line of Conscience." Then he filled in the words from the top, "Love, Life and Lineage." He eventually erased it. Later in his talk he returned to this theme by drawing three perpendicular lines on the board and explained that their point of intersection is the "sa ui guidae" – the four-position-foundation point. He proceeded to draw in the air with his hand, the same diagram that he had drawn at the beginning. This is another way to talk about the dynamics of the four-position-foundation referencing love, life, lineage and conscience.

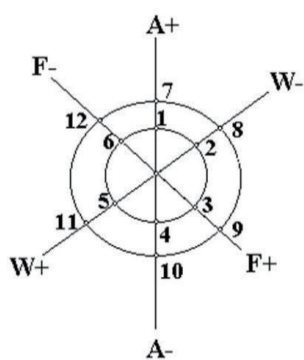
Since "the Way, the Life and the Truth" can represent the Holy Trinity, we can see that the Baptist Doctrine of Conscience has a similar form and meaning to Rev. Moon's "doctrine" (diagram) of Love, Life, Lineage and Conscience. The Baptist Doctrine of Conscience proclaims that kings and popes cannot answer for me in front of the throne of God on judgement day, and that my only lord that I will bow to is therefore my own conscience as it is inspired by the Father, the Son and the Holy Spirit. This view of conscience as inspired by God came to America with the pilgrims in 1690 and helped inspire Thomas Jefferson in his writing of the Declaration of Independence (1776) and the Virginia Act for Establishing Religious Freedom (1777) during the American Revolution, directly leading to freedom of religion in America.

2.7. Conjecture: The periodic table of elements can map to the Tree of Life. But is it correct to do so?

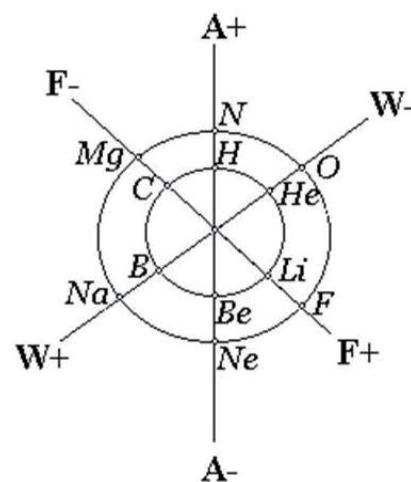


The Natural Array Tree of Life of Judaism has three columns representing water, air and fire, as well as three rows representing the complementary pole of water, air and fire. Why not map these to the periodic table of elements? Water, air and fire combine to form earth as the 4th element. This reminds us of the classical pre-Socratic four element theory that is considered superstitious and unscientific. Here is a diagram of the four element theory in Latin by Leibniz, the German polymath from the 1600's.

The Jewish Kabbalah, however, does not view these four elements of air, water, fire and earth in a materialistic manner, but in a deeply spiritual manner. Perhaps we should take another look at the four elements theory as it applies to the modern periodic table of elements. Considering odd numbers to be positive and even numbers to be negative, we can map the numbers and columns of the Natural Array Tree of Life the periodic table based on the atomic number of each element. The simple pattern is as illustrated in the following diagrams:



Notice that carbon, hydrogen and oxygen are on the fire, air and water columns respectively. They combine to form carbohydrates, which might correspond to earth. Carbon, lithium, fluorine and magnesium are all on the fire line, either on the plus or minus half of the line. Do they have anything to do with the masculine or feminine aspects of fire as characterized by the Jewish Tree of Life?



Does this make any sense from a modern chemistry or physics point of view? Does it

allow us to predict anything useful? The rest of the table follows by making larger and larger circles. Titanium, for example, is element 22 and is on the air minus line. The central air column of the Tree of Life represents Will. Titanium is strong and used in aircraft and memory metal. This might be pre-Socratic superstition, but then again, if the invisible blueprint in the mind of God was used to create the visible, physical world, then why would this conjecture not be correct? If it works, it might allow us to better formulate materials with special properties.

3. Conclusion

The traditions briefly discussed above each have symbols and processes that map to the four-position-foundation and its expansion as the ten-position Natural Array Tree of Life structure of Judaism and Hinduism, in particular. Every give and receive process also represents the four-position-foundation. The four-position-foundation is inside us and all around us. Some might make the critique that it is so simple that it can be easily trivialized. Nevertheless, when probed more deeply, it can explain everything, even answers to questions that we haven't thought of asking.

I didn't have space to give Unification Thought its own section. However, as I was studying the material over the last 30 years, I wondered around 1998, how exactly the Tree of Life of Judaism relates to Unification Thought. Shortly thereafter a big vision of old Dr. Lee's bright, smiling face appeared in front of my computer monitor and remained there for about 5 minutes. Three days later I drew a diagram that I think shows how the Unification Thought two-stage process of creation relates to the Jewish Tree of Life.

For further inspiration to investigate, consider Rev. Moon's words from "God's and Our Decision", Feb. 1, 1987.

"When you read my book of sermons, God's Will and the World, you can see that I have spoken the truth plainly and boldly. There are no more symbols or parables. I have set everything before you. The truth has emerged; this is real knowledge, the knowledge that you need. Who decided the heavenly four-position foundation? This is God's original principle. No human being devised it. Without going this route no one enters the Kingdom of Heaven."

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St. Paul's Fight to Implement Universal Values in the Book of Galatians

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Abstract: It is true that numerous scholars and researchers have published various studies on Paul's missionary activities, and especially his fierce struggle against his opponents. But their theoretical analyses are indifferent to the concrete reality of life that would have caused such struggles, in practice. Because the focus is only on the actual content of the narrative, the true nature of the antagonist is not properly revealed. Therefore, this study attempts to examine what really happened in the Galatian church and the fundamental issues behind the controversy, as revealed in the Epistle to the Galatians, which most clearly reveals Paul's struggles against those who opposed him. The purpose of this examination is to reveal the reality of the conflict, the issue of circumcision for Gentile and at the same time to correctly understand Paul's gospel. The cases of 'the Early Jerusalem Apostolic Council' (Gal. 2:1-10) and 'the Antioch Incident' (Gal. 2:11-14) show that Paul was trying to explain the non-discrimination that Gentile Christians, who were racially and socially disadvantaged, enjoyed equal in Christ. It clearly shows that he has consistently fought throughout his life to protect an equal life, or the 'truth of the gospel.' 'You are all children of God' (verse 26), and 'you have clothed yourselves with Christ' (verse 27). There is no difference between Jew and Greek, slave and free, male and female; all are one in Christ Jesus.' (verse 28). If Paul's declaration had not been made, and if Paul had collapsed in this struggle, the gospel of Christ would have remained a sect of Judaism, and God's providence of salvation would have had to go through a longer period of time and a process of indemnity. This is because his declaration that 'everyone is one in Christ' is the same as our ideal of building a peaceful world of Co-existence, Co-prosperity and Co-righteousness, which is a task that we must realize as members of the Christian community and is also the will of God.

Keywords: Universal Values, Book of Galatians, St. Paul

1. Introduction

2,000 years ago, Jesus Christ came to fulfill God's Will, which the first human beings, Adam and Eve, were unable to accomplish due to their fall while still in an immature state. But Jesus Christ was unable to fulfill that Will, due to the disbelief of the chosen people of Israel. He had to leave it behind and go the path of suffering on the cross, promising to 'come again.' Over the past 2,000 years, Jesus Christ has been recognized as the figure who has had the most significant impact in human history. The Bible is known as a 'bestseller' throughout the East and the West, even today, as many advanced countries are Christian countries. It is hard to deny that the influence of Christianity remains unsurpassed. Unfortunately, even though the core message of the Christian gospel preached by Jesus Christ is 'love and peace,' the world today is suffering from conflicts and struggles, especially between races, religions, and ideologies, and one cannot help feeling sad and discouraged. We are forced to contemplate whether it is truly impossible to realize God's ideal of creation, 'a world of peace as one human family of symbiosis, co-prosperity, and justice.'

In this context, I would like to share my reflections on the deeds of the apostles who led the movement to universalize the gospel of Jesus Christ 2,000 years ago. In particular, I would like to shed light on the struggles faced by the Apostle Paul in the course of his life.

2. St. Paul's Fight to Implement Universal Values, in the Book of Galatians

After Jesus' crucifixion, the apostles who followed him devoted themselves to spreading the gospel of Christ, suffering all kinds of persecution and martyrdom in the wake of Jesus' resurrection. Especially Paul, who had been a key figure in persecuting Christians, devoted himself to universalizing the gospel after meeting the resurrected Jesus on the road to Damascus. After his conversion, he was eager to spread the gospel of Christ to the ends of the earth, putting aside all earthly concerns. Of course, until now, numerous scholars have studied and

theorized about Paul's world missionary activities, and especially his struggles with his adversaries. However, the true nature of the conflicts he faced hasn't been clearly explained.

This study aims to examine the fundamental issues behind Paul's disputes with his adversaries, based on the Galatians epistle, where these conflicts are most vividly revealed. By doing so, hopefully we can discover the essence of Paul's struggles and gain a proper understanding of his gospel.

Paul consistently fought for fair and equal treatment of the Gentile Christians, who were socially and racially marginalized, within Christ. He saw this as protecting the 'truth of the gospel.' The Bible describes the 'Jerusalem Council'(Galatians 2:1-10)[1] where Paul met with James, the younger brother of Jesus, as well as Peter and John. Paul brought Titus, a Greek convert, to this meeting, and got all those in attendance to agree that, as a Gentile, he need not be circumcised. Also, in the 'Antioch Incident' (Galatians 2:11-14) [1], Paul criticized Peter for behaving differently in front of Gentiles and Jews, and for trying to force Gentiles to follow Jewish customs. He insisted that this was not necessary, as all were equally saved through the crucifixion of Jesus, as long as they believed in him. Paul endured hard labor, tribulations, and persecution solely for the sake of the gospel, considering all else as 'rubbish.' (Philippians 3:8) [1] He made himself a servant of all (1 Corinthians 9:19) [1]. He encouraged his followers to act as law-abiding Jews to win over the Jews; to act like those who live without the law, in order to win them over; and to act like the weak, in order to win those who are weak (1 Corinthians 9:19-22) [1]. He told them to do everything so as not to cause offense to either the Jews or the Greeks or the church of God. He confesses that he worked hard to please people and seek their benefit (1 Corinthians 10:32-33) [1].

However, we see in several other parts of Paul's epistles a side that differs from this confession, namely, that he confronted 'false brothers' (2 Corinthians 11:26) and 'false apostles' (2 Corinthians 11:13) [1]. He argued fiercely and fought desperately against his opponents, whom he referred to as 'dogs', 'evildoers' and 'mutilators of the flesh.' (Philippians 3:2) [1].

Through Galatians 1:6-10, we learn that the Galatians were committing apostasy by turning to 'another gospel,' and that there were people behind this who were disturbing them and distorting the 'gospel of Christ.' And through the text of Galatians 5:7-12, we can infer that the critical situation of the Galatian church was caused by the issue of circumcision, and that obedience to this circumcision ritual threatened the 'truth of the gospel.' Paul warned about this and emphasized it again in 6:11-17 [1]. Paul emphasized that the act of circumcision jeopardized the 'reality of salvation' the Galatians were enjoying within the 'truth of the gospel.' He said they were justified by faith through the Holy Spirit. He was making an evangelical declaration, telling them he was embracing them. Paul believed that if Gentile Christians, who were culturally and socially weak, were forced to undergo circumcision, they would be deprived of their 'freedom in Christ,' that is, 'the right to become God's people without being circumcised,' which is the 'gospel.' It was something that could never be tolerated as it went against the 'truth.'

3. Conclusions

This fact is especially evident in Galatians 3:26-29:

'You are all children of God' (verse 26), and 'you have clothed yourselves with Christ' (verse 27). 'There is neither Jew nor Gentile, neither slave nor free, nor is there male and female, for you are all one in Christ Jesus.' (verse 28) [1]. This statement by Paul can be seen as a declaration of equality, or restoration of rights for the Galatian believers, who were confronted by 'agitators' demanding that they be circumcised, and were immersed in uncertainty and confusion. If there had been no Paul, or if Paul had surrendered in this battle, the gospel of Christ would have remained a sect of Judaism. In that case, we can surmise that God's providence of salvation would have taken a longer period and gone through a process of indemnity. Paul, who opened the door to God's providence of salvation 2,000 years ago by breaking down the high wall of discrimination between Jews and Gentiles and globalizing the gospel of Christ, was a true worker of God and a true apostle of Christ.

The language of Galatians, which vividly depicts the reality of Paul's struggle, transcends the long passage of time and still echoes passionately in the hearts of believers today. It was Paul who declared that 'everyone is one in Christ.' This is because it is God's will that we must realize the ideal of one human family and a peaceful world where everyone shares universal values, as taught by Rev. Sun Myung Moon and Dr. Hak Ja Han Moon.

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Reconsidering the Concept of Rebirth in the Era of Cheon Il Guk

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Abstract: There are two different aspects to explaining the concept of rebirth in the 'Christology' chapter of the Divine Principle: 1) being engrafted upon the perfected Adam as the tree of life and 2) being reborn through True Parents. With these two aspects connected, the role of the perfected Adam becomes primary, providing the seed of a true blood lineage while the role of the perfected Eve is to provide a field for the seed to grow. To fully grasp a balanced view of rebirth, this paper proposes that the tree of life should be understood as the tree of True Parents, upon which humankind must be engrafted.

Keywords: Rebirth, Divine Principle, Christology, Begotten Daughter

1. Introduction

What is Rebirth? Section 4 'Rebirth and Trinity' in Chapter 7 of Exposition of the Divine Principle [1] has served as the basic text regarding the concept of rebirth in the FFWPU. The purpose of this paper is to introduce and reflect on the concept of rebirth in the Divine Principle from a new perspective, focusing particularly on clarifying the two logics of rebirth it contains: engrafting and procreation. As discussed later, the logic of engrafting to the tree of life maintains a male-centered view within the context of the providence of restoration, which weakens the logic of procreation. The concept of rebirth needs to be re-established with a logic of procreation centered on the love of True Parents in the Cheon Il Guk era, the world of God's ideal of creation.

In this regard, this paper first approaches the concept of 'human being who has fulfilled the purpose of creation' presented by the Christology in the Divine Principle from the perspective of the True Parents. This attempt is a prerequisite for overcoming the male-centered view inherent in the logic of engrafting. Following this, the paper introduces the concepts of engrafting and procreation, the two logics of rebirth, and coherently articulates the concept of rebirth for the era of Cheon Il Guk centered on the logic of procreation, where the true love of True Parents equally involves Heavenly Parent at the core. To this end, it interprets the tree of life not just as a man who has fulfilled the purpose of creation but as the 'tree of the True Parents,' where a man and a woman who have fulfilled the purpose of creation become one in love. Lastly, it discusses the significance of True Mother in the process of procreation, fully revealing the messianic value of the Only Begotten Daughter, True Mother, which has not been sufficiently highlighted due to the logic of engrafting.

2. Discussion

2.1. Human Beings Who Have Fulfilled the Purpose of Creation and the True Parents

According to the Christology in the Exposition of the Divine Principle, Jesus is "a man who has completed the purpose of creation." "There is no greater value than that of a person who has realized the ideal of creation. This is the value of Jesus, who surely attained the highest imaginable value" [1]. When Jesus, the Messiah, is called the human who has fulfilled the purpose of creation, we must consider what it means to fulfill the purpose of creation and how it can be accomplished. The Divine Principle directs us to refer to the first chapter, "The Principle of Creation," to understand how humans can fulfill the purpose of creation.

God's purpose of creation is achieved in the world in which the "three great blessings are fulfilled" [1]. Here, the three great blessings refer to: the perfection of individual character through the unity of mind and body centered on God (the first blessing), the perfection of the family through the loving oneness of man and woman as one (the second blessing), and the perfection of a human being's dominion over the natural world through the mutual giving and receiving of love and beauty between humans and all things (the third blessing) [1].

If the fulfillment of the purpose of creation presupposes the realization of the three great blessings, it leads to the conclusion that an individual cannot fulfill the purpose of creation. An individual can achieve the first blessing but not the second. The following passage from the Divine Principle supports this point: “The place where Adam and Eve become perfectly one in heart and body as husband and wife is also the place where God, the subject partner giving love, and human beings, the object partners returning beauty, become united. This is the center of goodness where the purpose of creation is fulfilled. Here God, our Parent, draws near and abides within His perfected children and rests peacefully for eternity” [1].

When the human ancestors, Adam and Eve, who have fulfilled the purpose of creation, become one with God at the center, they manifest as the True Parents of Heaven, Earth, and Humankind. In other words, God’s purpose of creation is fulfilled through the manifestation of the True Parents of Heaven, Earth, and Humankind. Their position is the place where true love, true life, and true lineage can unfold, and it is the central place where the incorporeal and corporeal worlds can harmonize through love.

Therefore, the concept of a ‘human who has fulfilled the purpose of creation’ needs to be redefined from the perspective of the True Parents, not as an individual. This issue is crucial when discussing the origin and method of rebirth. If we see the being who has fulfilled the purpose of creation as an individual (male), the key to rebirth would be to be engrafted to him. Even though a woman is needed for rebirth, she would be only a necessary condition for childbirth, not sufficient to change the lineage. This is the logic of the current Christology in the Divine Principle, which needs reinterpretation from the perspective of the Principle of Creation and the True Parents

2.2. *Two Logics of Rebirth: Engrafting and Procreation*

2.2.1. *Engrafting onto the Tree of Life*

The Divine Principle consistently presents the view that a person who fulfills the purpose of creation is an individual and a man. This is clearly illustrated in the explanation of the ‘Tree of Life.’

Had Adam fully realized the ideal of creation, he would have become the tree of life and likewise all his descendants would have become trees of life. However, Adam’s fall frustrated God’s Will, and ever since, fallen humankind has hoped to be restored as trees of life. Since a fallen person can never fully restore himself as a tree of life by his own efforts, a man who has completed the ideal of creation must come as the tree of life and engraft all people with himself. Jesus is this tree of life portrayed in the Bible [1].

What does it mean that if Adam had become the man who completed the ideal of creation, all his descendants would have become trees of life? Here, the tree of life refers to a man who has fulfilled the ideal of creation, and his descendants would naturally include not only men but also women, implying that ‘descendants’ means ‘humans’ without distinction between male and female. In other words, the Divine Principle uses ‘man who has completed the purpose of creation’ and ‘human who has completed the purpose of creation’ interchangeably. Man thus becomes the archetype of human beings.

The reason fallen humans cannot restore themselves to the tree of life by their own strength is that returning to the tree of life means a change of lineage. Humans, as beings who are the result of creation, cannot change their lineage by their own power once they are born. To change lineage, they must be reborn with different parents. The Divine Principle states that for fallen humanity to be restored to the tree of life, i.e., to change their lineage, they must be grafted onto a man who has completed the ideal of creation and come as the tree of life. Although rebirth requires both a father and a mother, the source that determines the identity of the lineage lies with the father. This is the implication of the first logic of rebirth, ‘engrafting.’

Engrafting, as illustrated in Romans 11:17, means that fallen humans symbolized by the wild olive tree are grafted onto Jesus, symbolized by the true olive tree, and are given new life from the sap of the true olive tree, that is, the true lineage. This logic of grafting aligns with the analogy of ‘seed and field.’ The man provides the seed, the origin of the fruit, and the woman provides the nutrients as the field to sprout the seed. “Eve does not have the seed, does she? Eve is the field. [...] The tree of the knowledge of good and evil refers to the woman’s love centered on Eve’s love. No matter how wicked a woman is, she can go to a good king, and no matter how good a woman is, she can go to a bad king” [2].

This perspective reflects the context of the providence of restoration through indemnity. Due to the fall in the Garden of Eden, a world of sin emerged where Satan (the archangel), centered on selfish desires, ruled Adam, who in turn ruled Eve, and Eve ruled Cain, and Cain ruled Abel. To restore this, the providence of restoration must begin with Abel, who is the furthest from Satan. When Cain submits to Abel, and Eve cooperates with her sons, an indemnity condition can be established, signifying the removal of the fallen nature introduced into humanity's lineage. On this foundation, the new Adam, the male Messiah as the tree of life, appears, defeats Satan, and through him, new life of the true lineage is infused, allowing humanity to be reborn and saved. The logic of grafting onto the tree of life emerges from this context of the providence of restoration through indemnity.

The Divine Principle clearly states that the Messiah comes as True Parents. Although the subject of grafting is the male Messiah as the tree of life, a mother is necessary to give birth to children again. Therefore, the male Messiah must take such a woman as his wife to become True Parents and rebirth humanity. As mentioned at the beginning, from the perspective of the providence of restoration through indemnity, the role of True Mother is necessary for the rebirth of humanity, but it is not sufficient. The Divine Principle emphasizes, "a father alone cannot give birth to children. There must be a True Mother, as well as a True Father, for fallen children to be reborn as good children" [1]. However, as seen in the analogy of seed and field, the true seed, true life, and true lineage come from the father, and the mother merely plays the role of the field that sprouts the seed. This extreme perspective could lead to the notion that as long as there is a True Father, it does not matter who the True Mother is. But is this really so?

The logic of engrafting can potentially confuse the entire logic of rebirth centering on True Parents. It can create a hierarchical distinction in the roles and values of True Father and True Mother in rebirth. This can conflict with the view of the Principle of Creation, which states that the completion of the purpose of creation is achieved not by an individual (man), but through the position of True Parents. We need to prioritize the equal and complementary concept of True Parents from the original perspective of creation and apply it to the context of the providence of restoration through indemnity. It is because True Parents are the unique, once and for all, existence in human history, ending the era of the providence of restoration through indemnity and opening the original world of creation

2.2.2. Procreation through the Love of True Parents

From the perspective of the Principle of Creation, Adam and Eve are in the position of 'twin embryos,' each resembling the masculine and feminine characteristics of Heavenly Parent. Therefore, if the substantial foundation to give birth to the Only Begotten Son is established, Heaven can also give birth to the Only Begotten Daughter on that foundation. However, due to the failure of Zachariah's family, Joseph's family, and the Jewish people to fulfill their responsibilities, the birth of the Only Begotten Daughter was ultimately thwarted. Jesus was left with no choice but to walk the path of the cross, leaving the promise of his return.

What is noteworthy here is that the foundation for the birth of the Only Begotten Son also serves as the foundation for the birth of the Only Begotten Daughter. Therefore, another providence of lineage restoration is not needed for the birth of the Only Begotten Daughter. Moreover, the Only Begotten Daughter does not come from among fallen humans but appears as the direct Daughter of Heavenly Parent, just like the Only Begotten Son.

Although the Divine Principle presents a male-centered grafting logic, it also provides a perspective based on the Principle of Creation: "Parents who have original sin cannot give birth to good children who do not have original sin. Certainly, it is impossible to find sinless parents among fallen humankind. These parents must descend from Heaven" [1]. Therefore, the True Mother is not a woman found among fallen humans but the Only Begotten Daughter sent directly by Heavenly Parent. This expression in the Divine Principle at least prevents an extreme interpretation of the grafting logic. The interpretation that as long as there is the seed of the heavenly lineage, it does not matter who the field is, is clearly wrong.

It is time to reinterpret the male-centered grafting logic. This can start from clarifying that the perfected human, who fulfills the purpose of creation, is not a single man but a male and female human ancestor who have achieved oneness with Heavenly Parent in true love, that is, the True Parents of Heaven, Earth, and Humankind. In other words, the tree of life and the true olive tree symbolize the "tree of True Parents," which represents a man and a woman who have both perfected the ideal of creation. From this perspective of the tree of True Parents, a new understanding can emerge that both the perfected Adam and Eve are trees of life. The following words of True Father support this view: "In the Bible, everything is about the tree of life. There is a tree of life in the Garden of

Eden, and then there is also a tree of life in Revelation. What that means is the perfection of Adam and Eve. The perfection of Adam and Eve is simultaneously the perfection of God" [3].

In conclusion, even though the Divine Principle may seem to suggest a hierarchical distinction in the rebirth process through its grafting logic, the essential perspective on the original world of creation emphasizes the equality and complementarity of True Parents. The logic of procreation through the love of True Parents in the concept of rebirth resonates with the fact that both the Only Begotten Son and the Only Begotten Daughter are sent by Heavenly Parent directly on the same providential foundation. Therefore, the concept of rebirth needs to be focused on the logic of procreation in the era of Cheon Il Guk.

2.3. The Importance of the Mother for Rebirth

Understanding how the created world exists is essential for comprehending the nature of Heavenly Parent. This world, created according to the 'law of resemblance in creation,' mirrors Heavenly Parent. The process of human birth provides crucial clues about not only the Heavenly Parent's creation of humans but also how rebirth is accomplished.

As mentioned earlier regarding the seed and field analogy, in the past, it was believed that a man's sperm, like a seed, played a decisive role in the birth and traits of a baby by settling in a woman's ovum, like a field. However, with the advancement of science, it has been revealed that the emergence of life depends on genetic information contained in DNA (deoxyribonucleic acid) and RNA (ribonucleic acid), akin to a blueprint of existence. Each of the approximately 60 trillion cells that make up a human being contains DNA with identical genetic information in its nucleus. Human life begins from a fertilized egg, formed by the combination of male and female reproductive cells, sperm and ovum. Since sperm and ovum each carry half of the DNA from the father and mother, the combined fertilized egg contains the same amount of DNA as the parents. In other words, the DNA that plays a decisive role in forming human traits is a new combination of half the DNA from the father and half from the mother, creating a unique blueprint of existence. Based on this genetic information, the fertilized egg undergoes cleavage and cell division, progressing from an embryo to a fetus and eventually developing into a complete human being.

These scientific discoveries have made the traditional seed and field analogy untenable. The field cannot significantly influence the genetic information contained in the seed; it merely provides the nutrients for the seed to grow. However, human sperm and ovum each transmit equal amounts of genetic information to their offspring, producing children that resemble both parents. Although sperm and ovum differ in size, shape, and motility, they are the same in that they each carry 50% of the father's and mother's DNA. If we were to maintain the seed and field metaphor, the 'seed' for human birth would not come solely from the father; the fertilized egg itself, formed by the combination of sperm and ovum, becomes the seed of life.

This interpretation highlights the newfound importance of the mother in the birth of life. While both parents contribute equally to the formation of the fertilized egg, the process of the fertilized egg developing into an embryo, a fetus, and eventually a newborn is entirely the mother's role. During the ten months the baby spends in the mother's womb, it receives nutrients from the mother, listens to her heartbeat, shares her emotions, and directly experiences prenatal education.

According to True Parents' teachings, human life comprises three stages: ten months of fetal life in the mother's womb, 100 years of earthly life, and eternal life in the spirit world. One of these stages, fetal life, is fundamentally rooted in the mother. This emphasizes the importance of not only birth but also the mother's womb life in human existence. During this period, the mother forms a direct emotional relationship with the fetus, providing the necessary content for the formation of the fetus's mind and body, laying the foundation for the growth of both character and personality. From this perspective, True Mother says, "In the birth of a child, the mother bears 99.99 percent of the responsibility."

Furthermore, the labor of childbirth is entirely the mother's responsibility. Although medical advancements have significantly reduced maternal mortality during childbirth, it remains a moment of tension, where the mother exerts her utmost effort to give birth, and the baby, likewise, struggles to emerge into the new world. The Heavenly Parent is said to have created this world and humanity with absolute faith, absolute love, and absolute obedience, which means completely emptying oneself and absolutely investing everything for the sake of the other. A mother's labor mirrors this sublime commitment of absolute faith, love, and obedience. The baby responds to the mother's love with absolute effort, heralding its arrival into the world with a strong cry.

Through this process of mutual absolute faith, love, and obedience, an inseparable blood relationship is formed between the mother and the fetus. It is a miraculous event where a new life is born through the ultimate commitment. Cutting the umbilical cord signifies the beginning of this blood relationship. Traditionally, the issue of lineage has been viewed from a male-centered, patriarchal perspective. However, we must reconsider the relationship formed during childbirth as one of absolute faith, love, and obedience between the mother and child, along with a new perspective on the 'seed'. Similarly, in the creation of humans by the Heavenly Parent, it was not merely the Heavenly Father acting as an architect from nothing but the Heavenly Mother who, through her amazing devoted love, gave birth to humans as direct children.

When we synthesize these perspectives, we recognize anew the crucial role of the Heavenly Mother and True Mother in the rebirth of fallen humanity. The new life seed for lineage transformation does not come solely from True Father but from the fruit of the love of both True Parents. We must not forget that the arduous process of rebirth involved True Mother's labor pains.

In an environment where Christianity did not provide the foundational support, the path of True Parents over the past 60 years has resembled a wilderness course. Nonetheless, as parents, they have given their utmost effort, resulting in numerous blessed families worldwide today. Humanity needs True Parents to return to the Creator God. Without True Parents, this return is impossible. In other words, rebirth and resurrection, being born again, must occur through True Parents, a process known as the blessing. The Creator God is the Heavenly Parent of humanity. True Parents have expanded the path for humanity to advance toward the Heavenly Parent over the past 60 years.

The 60 years mentioned by True Mother symbolize her labor and womb life in giving rebirth to fallen humanity. True Mother has continually invested immense love to enable humanity to be reborn into the original world of creation, the environment of Cheon Il Guk, to live as children of the Heavenly Parent, a commitment she continues to uphold without interruption. Humanity must recognize the labor of the Only Begotten Daughter, True Mother, and the devoted love of the Heavenly Mother.

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Proceedings of

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Poster Session

Agroforestry tree cover change in agricultural landscapes following farmland enclosure in Tigray, Ethiopia

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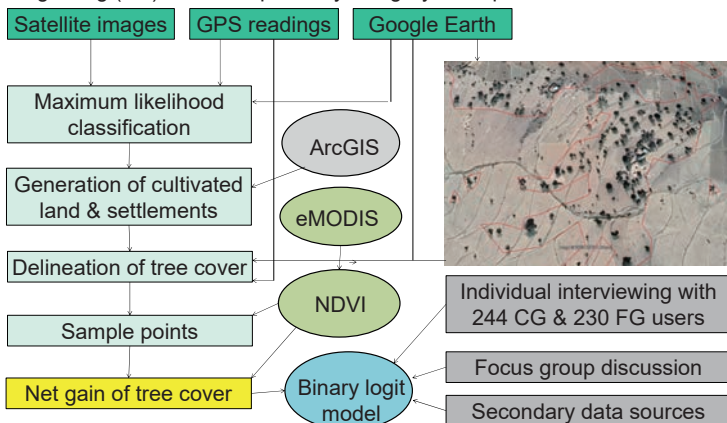
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Introduction

- Agroforestry (AF) practices have been implemented by subsistence farmers throughout the world[1].
- However, free and overgrazing after crop harvest is one of the main challenges in AF expansion in Ethiopia [2].
- Farmland enclosure with controlled grazing (CG) has been introduced to increase tree cover in agricultural landscapes (AL).
- However, evidence of tree cover trends with grazing systems (GS) is limited despite the global commitments to increase tree cover in AL.
- The aim of the study was to analyze the trends of tree cover in AL related to GS & other dynamic factors.
- Knowing the trends of tree cover has great interest to a variety of scientific & appropriate land management interventions.

Methods

- For this study, 5 & 6 villages were randomly selected from CG & free grazing (FG) users, respectively in Tigray, Ethiopia.



Results

Table 1: Trends of agricultural area under tree cover over 2004 - 2020 in CG and FG

Grazing system	Area in 2004 (ha)	Area in 2011 (ha)	Area in 2020 (ha)	Change 2004-2011 (%)	Change 2011-2020 (%)
CG	389.1	571.5	952.4	46.9	66.7
FG	284.2	336.7	418.7	18.5	24.3

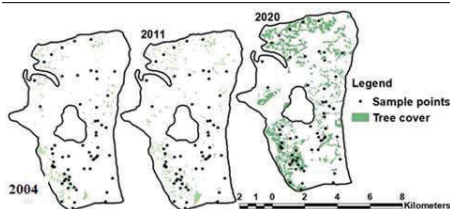


Fig. 1: Tree cover change in AL of CG dominated village after introduction of farmland enclosure in 2011

- There was a net gain of AF tree cover from 2004 to 2020 in both GSs due to land rehabilitation initiatives [3].
- The increase in AL under tree cover was significantly higher in CG (120.3%) than in FG (29.9%) from 2011-2020 (Table 1) as regeneration of trees could be damaged by livestock during FG.
- The respondents confirmed that AF tree cover increased on their lands.
- Majority of the AL was covered by low NDVI value in both GSs as the study area was dominated by deciduous trees.

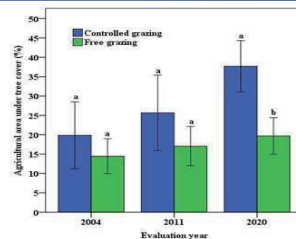


Fig. 2: Proportion of AL under tree cover in CG & FG over 2004 - 2020

- The proportion of AL under tree cover increased from 19.1 to 26.9% with a rate change of 49.1% between 2011 and 2020 (Fig. 2).

Table 2: Factors affecting AF tree cover change (Binary logit model)

Variable	2004 - 2011		2011 - 2020	
	B	S.E	B	S.E
Farmland proximity to homestead	1.302***	0.229	2.926***	0.279
Grazing system			3.371***	0.306
Livestock density	-0.002*	0.001	0.001	0.001
Net gain of cultivated area	0.120***	0.038	-0.018**	0.038
Uncultivated land size	-0.001***	0.001	0.001	0.001
Household density	6.940	5.407	-0.127**	0.062
Herd size	0.019*	0.010	0.033*	0.018
Farmland size	-0.884***	0.221	-0.574*	0.326
Net gain of settlements area	0.018**	0.009	0.005*	0.003
Average rainfall	0.006***	0.002	0.003**	0.001
Average temperature	0.186**	0.084	-0.158***	0.055
Cox & Snell R ²	0.43		0.51	

* = P < 0.1, ** = P < 0.05, *** = P < 0.01

- The underlying factors affecting the trends of AF tree cover varied over time (Table 2).
- Besides CG, rainfall, farmland proximity to homestead, temperature, herd size, cultivated land and settlement expansion, and household density contributed to the tree cover change.
- Expansion of settlements increase tree cover if new homesteads are established in areas with low tree density.

Conclusions

- CG enhanced tree cover in AL
- The net gain of tree cover had been affected not only by CG but also by the dynamic of climatic & demographic factors, household & village characteristics.
- The farmlands which are located far away from homesteads were without tree cover in FG dominated areas.
- These results implied that context based AF practices with sustainable grazing is essential to increase tree cover in AL.
- Therefore, supporting policy and guideline that curtail FG while providing alternative feeding strategies are essential for expansion of tree based farming system.

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2024 International Joint Conference
4th ICHJA & 21th ICUMS & PWPA 2024 & WRIST 2024

Aug. 22-24, Sun Moon University (Asan) and HJ Magnolia Hospital (Cheongpyeong), Korea (on & offline)

Step-skew design of surface permanent magnet synchronous machine for EPS system using cycloid curve

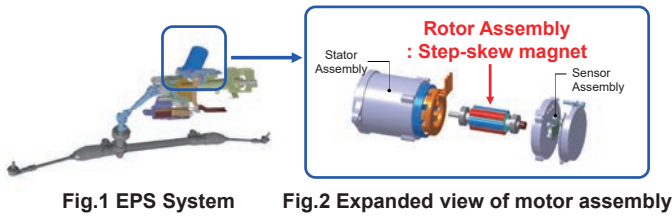
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Introduction

- Research background
 - . Cogging torque : torque pulsation at no-load drive of motor
 - . Cogging torque reduction
 - : Key design factor of EPS (Electric Power Steering) system for enhancement of steering feeling and NVH
- Research objective
 - . Conventional design method : step-skew design
 - : Increasing of manufacturing costs due to multi step-skew
 - . A novel design method proposal of step-skew design
 - : Cogging torque reduction for reducing step-skews with cycloid curve on permanent magnet



Base model

- Main specification
 - . 6Poles 9Slots SPMSM with O.D 84mm and stack length 48mm
- Index value of δq to compare models
 - . Magnet shape design for conventional and proposed method

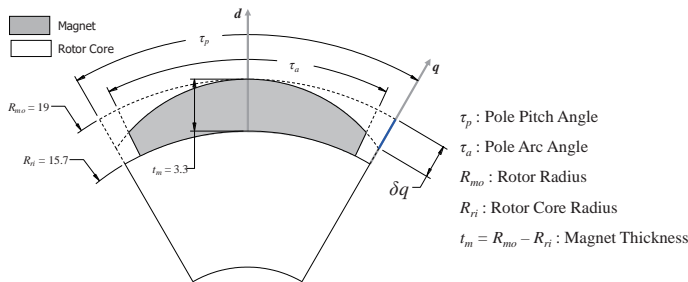
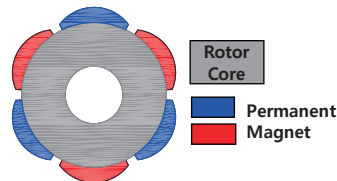
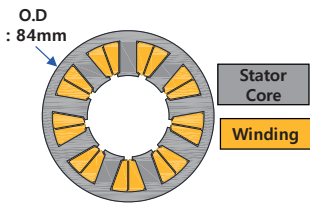


Fig.5 Definition of δq in magnet shape of rotor

Proposed model for manet shape

- Conventional model : Eccentric curve
 - . A circle has the eccentricity from the center point
- Proposed model : Cycloid curve
 - . A trajectory which a circle rotate, without slipping, on a circle

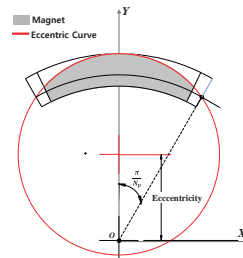


Fig.6 Eccentric curve

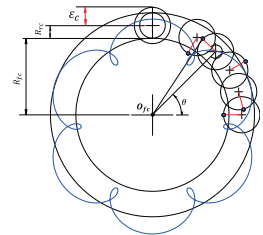


Fig.7 Cycloid curve

Analysis results

- Analysis method : Numerical analysis by FEM
 - . Non-linear properties of magnetic material and complex geometry
- Result value : peak to peak value of cogging torque for 1 period
 - . Selection of $\delta q = 4.5$: Effects of manufacturing tolerances

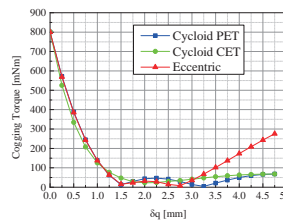


Fig.8 Analysis results for δq

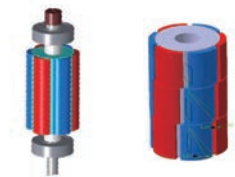


Fig.9 Non-skew and 3 step skew model in rotor

Table 1. Cogging torque with $\delta q = 4.5$

Skew model	Proposed model (Cycloid Curve)	Conventional model (Eccentric curve)
Non-Skew	64	236
3 step skew	2.5	11

Unit : mNm

Conclusions

- Comparison for proposed and conventional model
 - . Non-Skew model : Cogging torque reduction by 73%
 - . 3 step-skew model : Cogging torque reduction by 77%
 - **Competitive assembly cost reduction for low cogging torque**
- Future study : Validation of analysis results through prototypes

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Overseas Medical Service with Mother of Peace Create a path for the reunification of North and South Korea through "Medical Peace Road"

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Introduction



↑ 2nd gen medical personnel Song Gwang-seok President and in Seoul, 2023.11

Medical Peace Road born from the unification of Korea and Japan of medical professionals from 2022.

Medical professionals from around the world (Mozambique, Korea, Japan, USA, Australia) will gather in Sao Tome and Principe this August to develop medical services and create the continent of God's Africa.

'Medical Peace Road' believes that the unification of Korea and Japan through medical care can serve as a model for world peace, and by uniting Korean and Japanese medical practitioners, we will create a network of medical practitioners that will unite the hearts of the world's medical practitioners, globalize the foundation, and ultimately lead to the reunification of North and South Korea, and register as an NGO under the United Nations to create a path for the reunification of North and South Korea through medical care.

Experimental / Methods / Results



↑ October 6, 2019, True mother gathered Youth doctors in Nagoya

☆ Background of the birth of Medical Peace Road
On October 6, 2019, Dr. Hak Ja Han Moon convened second-generation Japanese medical professionals and spoke to them in her own words.

She said, "We must know the historical problems that Japan has caused," "We must be united with Korea," and "We must look for the righteous and help them in the will of God."

In June 2022, through an exchange program with the HJ Magnolia Global Medical Foundation, the annual Korea-Japan Future Talent Medical Training Program began in August. Through this program, we learned that the unification of North and South Korea is our responsibility, and that the unification of Korea and Japan through medical care is the path to world peace. In the midst of our desire to contribute to world peace through medical care, in 2023, Chairman Song, who was then in charge of the Peace Road, and the President of HJ Magnolia International Hospital gave us the name Medical Peace Road.



↑ March 27-April 7, 2024 During the HJ Magnolia Global Medical Foundation President's tour of Japan,

March 27-April 7, 2024 During the HJ Magnolia Global Medical Foundation President's tour of Japan, Signatures on the "Medical Peace Road" banner from medical professionals throughout Japan as a sign of their commitment to world peace through medicine.

April 20, 2024, Dr. Hak Ja Han Moon invited us to a special meeting of Korea-Japan Medical Future Talent.

She instructed us, "We must let people know what we have done and are doing for Japan and for the world," and "We must help the elderly Japanese food addicts who have devoted themselves to the world providence with our medical foundation.

She then signed the "Medical Peace Road" banner.



↑ April 20, 2024, Dr. Hak Ja Han Moon invited us to a special meeting of Korea-Japan Medical Future Talent and Participant List

Occupation	Composition
Doctors (Korea 2nd gen)	3
Nurses, Students (Korea 2nd gen)	4
Physical Therapist (Korea 2nd gen)	3
Doctors, Students (Japan 2nd gen)	21
Nurses, Students (Japan 2nd gen)	17
Physical Therapist (Japan 2nd gen)	2
Other	10



the 4th International Conference of Hyojeong Academia (ICHJA), the 21st International Conference for Unification Medical Science (ICUMS)

August 22 to 24 in Korea, Sun Moon University (Asan) and HJ Magnolia Hospital (Cheongpyung), Korea

Overseas Medical Service with Mother of Peace Create a path for the reunification of North and South Korea through "Medical Peace Road"

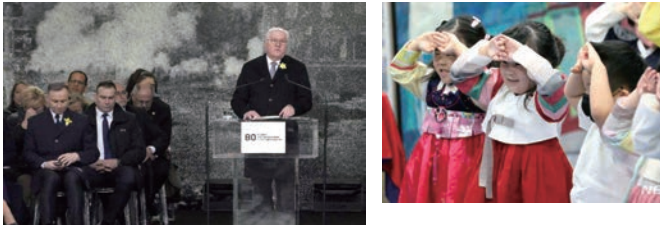
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Introduction



- ☆ The Value of Medical Service Across Borders
 - A sad chapter in history can be melted through heartfelt medical service. Sincere apology from the German President
 - Promote the Korean culture of filial piety to the world. Family culture becomes the pillar of the human family by honoring our parents, the Confucian culture of Korea.



↑ CONTINENTAL AFRICA December 27-29, 2019 National Party of Niger, Niamey, capital of Niger, Africa

Miracles happen when Korean and Japanese medical volunteers work together as one

At the 2019 Africa Summit in Niger, HJ Magnolia Global Healthcare Foundation President Kim Sang-gyun introduced the story of how Japanese doctors came to Korea 40 years ago to provide medical services in response to the African leaders' questions, "Does HJ Magnolia Global Medical Foundation have money, can it build a hospital, and can it send large amounts of medicine?"

Korea at that time was still suffering from the wounds of the Japanese and Korean wars, and he testified that Japan, which was the perpetrator in history, went to sick patients and areas where even Korean doctors would abandon them, and provided free medical care, which healed the wounds of Japan in the past, and a great revival occurred, and Korea became a highly developed country.



Of course, there is the aspect of overseas medical service, which is to bring in cutting-edge technology from abroad to help with the medical care that is lacking in that country, but beyond that, I am convinced that when two countries that were once enemies in history become one with our Heavenly Parent, it is a great opportunity to heal the wounds and create a way to live together as one family.

Just as Korea and Japan became one through the Medical Peace Road, the goal of our medical service is to create a path to unity across the borders of the world.



↑ Japanese medical professionals in Korea in 1971

- ☆ Vision
 - Building an international service network with youth leaders in various fields beyond medicine
 - Revitalization of the Cranes Club network

What is needed for Japan to become the Owner of peace in Asia is for Japan to repent of the mistakes it has historically made against Korea and Asia, and to take the lead in longing for the reunification of North and South Korea. Only then can God's (Heavenly Parent's) resentment be released.

It is the hope of the world that the Korean peninsula, which is still divided by the Japanese occupation and the national interests of neighboring countries, will be united as one people, and it is the axis that can solve the world's problems today.

Like the German President, Japan can stand at the Owner of Asia as it sincerely repents its history
Become a child of heaven who desires peace more than anyone else



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Selected scientific and technological achievements of WRIST in the early years

J. Andrew Combs

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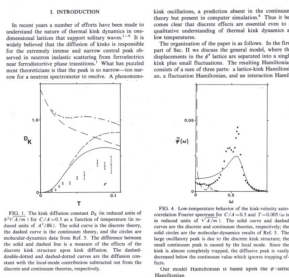
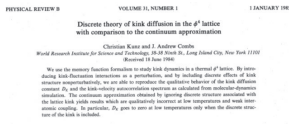
Introduction

- The World Research Institute for Science and Technology (WRIST) was founded by Rev. Moon in 1984.
- Developed a marine navigational aid with Loran and patented coastline compression called MasterNav
- Determined temperature behavior of soliton diffusion in atomic chains (Phys Rev B)
- Discovered 3-stage two-dimensional melting mechanism differed from proposed Kosterlitz-Thouless transition (Phys Rev Lett, and Phys Rev B)
- Gave birth two distributed software and electronics hardware firms InterLinear Technology and MicroSignals, respectively. The former created engineering document management software used by NASA as a mission-critical aid in the repair of the Hubble Space Telescope, by Tokyo Electric Power and Korea Electric Power for power plant maintenance.

Results

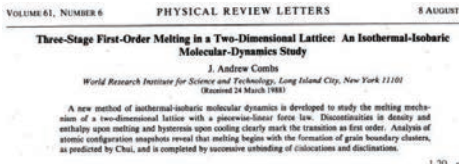
The first project was begun in 1983 under "Saeilo R&D", which later was named WRIST by Rev Moon shortly after scientists arrived. The result was a Loran that displayed position on a video-plotter called MasterNav that had

- weather-proof construction for the Alaskan environment
- a patented high speed high compression tile-vector coastline display capability



At the same time physicists used computer molecular dynamics of soliton "quasi-particles" on an atomic chain along with the memory (Green's) function formalism to clarify the behavior of the diffusion constant as a function of temperature [1]. By doing so it corrected conclusions from papers out of Universities of Chicago and Pennsylvania. Interestingly, the same Green's function approach is now being used by WRIST in analyzing climate change.

Later, computer molecular dynamics was used to study the a famous problem concerning the mechanism of melting in two-dimensions [2].

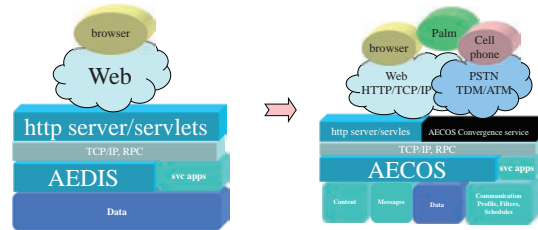


It was found melting was a 1st order process that took place in 3-stages: nucleation of grain-boundaries, dislocation-pair unbinding (closely related to the "KT" transition of Kosterlitz-Thouless who were later awarded the Nobel Prize) and disclination unbinding. The discovery was prompted by seeking "3-stages" due to the Divine Principles of Rev. Moon.

In 1990 two companies spun off from WRIST. One was an electronics hardware company called **MicroSignals, RF**, another was a software company **InterLinear Technology (ILT)** was formed after learning about distributed networked software in the UNIX environment.

Microsignals had electrical engineering expertise, developed crystal filters that were delivered to AT&T/Lucent. Later a meander-line coplanar ground plane hybrid diplexer needed by the cell phone industry was developed, and sold basically by word-of-mouth. High quality 2-way, 4-way, and 8-way power splitters even made their way into Air Force 1.

ILT was formed after learning about distributed networked software in the UNIX environment. A beautifully partitioned distributed software architecture called **AEDIS** (Agile Electronic Document and Information Solution) was built. Originally intended for local networks and intranets, on UNIX workstations, it easily migrated and adapted to Windows clients and browsers using http servers as the internet exploded on the scene.



AEDIS was adopted by NASA for the Hubble Space Telescope maintenance, by Tokyo Electric Power for power plant maintenance, Korea Electric Power, Samsung for its F-16 fighter project, GE Medical and many others.

As VoIP, fax and messaging became important, it was adapted to incorporate active messaging, fax delivery and VoIP – TDM convergence as **AECOS** (Agile Electronic Communication Operating System).

Conclusions

Following WRIST as formation stage, ILT/MicroSignals as growth stage, WRIST today is in the "completion Stage" working in areas of electromagnetic interactions with biological systems, spirit-physical interactions, and stewardship of Earth including climate change research, past conferences in Gifu Japan (2018) and Geissen Germany (2019).

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Exploring the Realm of Psychotronics: A Case Study of ESP in Czechoslovakia

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Introduction

Exploring extrasensory perception (ESP) in Czechoslovakia from the 1950s to the 1980s reveals a fascinating narrative. ESP, which includes phenomena such as telepathy, telekinesis, and clairvoyance, became a subject of scientific inquiry and public discourse.

This acceptance was intertwined with the evolving political climate, creating a unique ecosystem for exploring the paranormal. Psychotronics, a multifaceted field, explores the mind-body connection, consciousness, and human capabilities beyond conventional scientific understanding.

- **Mind-Body Interaction:** Investigates how the mind influences physical phenomena, using techniques like meditation and hypnosis (Tart, 1969).
- **Parapsychology:** Studies ESP, near-death experiences (NDEs), telepathy, and other phenomena beyond conventional science (Radin, 1997).
- **Altered States of Consciousness:** Uses meditation, hypnosis, and psychedelic drugs to explore hidden dimensions of consciousness (Grof, 1980).
- **Emerging Technologies:** Brain-computer interfaces (BCIs) and augmented reality (AR) push the boundaries of mind-machine interaction (Wolpaw & Wolpaw, 2012).

Leading Figures in Paranormal Studies

1) Břetislav Kafka (1891-1967)

He explored telepathy, clairvoyance, and body magnetism with hypnosis, influencing interdisciplinary research in Czechoslovakia (Kafka, B. 1963).

2) Professor František Kahuda (1911-1987)

He founded the Psychoenergetic Laboratory in communist Czechoslovakia, developing theories on "mental energy" and "thought particles" (Kahuda, 1982).

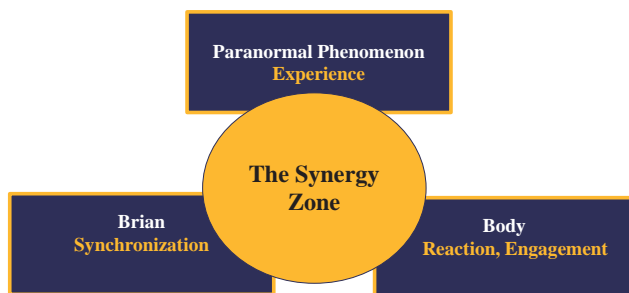
3) Father František Ferda (1915-1991)

He used an "informational field" for remote diagnosis and iridology, attracting a diverse clientele despite political persecution (Ferda, 1983).

4) Zdeněk Rejdák (1934-2004)

He pioneered psychotronics in Czechoslovakia, establishing the Institute for Parapsychological Research and coining "psychotronics" (Rejdák, 1974).

Connecting the Mind, Brain, Body and Paranormal Phenomenon



Towards a New Paradigm of Global Development

- The Unification Movement's research into vacuum energy and dark matter represents a bold vision for scientific and societal advancement. Recent conferences in Korea have highlighted the potential for a deeper connection with the universe and the Creator, reflecting Oswald Spengler's vision of the Pacific's rise in the 21st century (Spengler, 1922). South Korea's scientific endeavors, coupled with a pursuit of global harmony, establish it as a leader in sustainable and interconnected development.
- Despite criticisms directed at its methods, the Unification Movement remains dedicated to fostering open dialogue and intellectual engagement. Its scientific pursuits, such as harnessing vacuum energy, invite readers to imagine a future reshaped by these breakthroughs (Lanza, 2010; Laszlo, 2008).

Unifying Religion and Science

The Unification Movement integrates scientific discovery, spiritual guidance, and progress:

- **Embracing a Holistic Understanding of the Universe**
Scientific exploration of vacuum energy and dark matter aligns with the Movement's vision of a consciousness-infused universe. This holistic understanding could prioritize our well-being and environmental balance over mere economic growth.
- **Science and Religion/Spirituality**
The Divine Principle could revolutionize biophysics, neuroscience, and quantum mechanics, ensuring ethical advancements.
- **Peace and Interconnectedness**
The scientific quest for unified field theories and the discovery of intricate cosmic connections mirrors the Unification Movement's vision of a world free from conflict and division. By embracing the Unification Movement's emphasis on resolving conflict through dialogue and cooperation, we can envision a future where global governance fosters collaboration over competition, and cultural clashes transform into opportunities for mutual enrichment.

Conclusions

The exploration of extrasensory perception (ESP) in Cold War Czechoslovakia reveals the complex interplay between science, politics, and societal beliefs.

This historical analysis illustrates how social, political, and cultural factors influence scientific inquiry in mysterious domains.

Integrating scientific knowledge, spiritual harmony, and progress can lead to a future where science and spirituality coexist, fostering peace, interconnectedness, and universal well-being.

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The Unificationist Model of Spiritual Healing: Historical, Systematic and Future Perspectives

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I. Introduction

The Cheongpyeong (CP) Providence is central to Unificationist religious practice. Its aim is the liberation of evil spirits and ancestors. This has opened an avenue for the unique Unificationist experience of spiritual healing.

The CP Providence is an excellent case study that could offer a fresh perspective on a general dilemma faced by contemporary theology: How are religious doctrines on healing to be reconciled with a modern scientific medical paradigm?

Based on (1) historical and (2) systematic analyses of the CP Providence, this paper discusses (3) various future scenarios of the CP Providence. In light of the dynamic relationship between doctrine and practice, three pathways in which the CP Providence may develop in the near future are outlined.

I. Historical Perspective: The Shift in the Unificationist Doctrine of the Spirit World

Basic elements of the Unificationist doctrine on the “spirit world” were laid out in the *Wŏlli kangnon* (원리강론, WK). A crucial historical change to the idea of indemnifying sins and liberating evil spirits was introduced by Kim Hyo-nam (KHN) (see table 1).

	WK (1966)	KHN's Teaching (1995–2013)
Role of evil spirits	Subtle influences of evil spirits lead to anxiety, egoism, and illness	Evil spirits are attached to the physical body lead to physical, mental or economic problems
Aim of restoration	Resurrection, a gradual progression of spiritual development	Establishment of Ch'ŏnilguk (천일국) & support of blessed families living on earth
Indemnity of hereditary and collective sin	Not specified	<i>Ansu</i> , <i>ch'anyang yŏksa</i> , ancestor liberation & blessing
Locus of restoring evil spirits	The physical world, vitality elements necessary	Evil spirits are re-educated by Heung-Jin Nim in the spirit world

Table 1. Comparison between WK's and KHN's concept of the spirit world and the spiritual maturation process.

Significant theological problems arose from this doctrinal shift:

- (a) KJN's model downplays the 5% human portion of responsibility.
- (b) The CP Providence is highly institution-centred, potentially neglecting individual needs.
- (c) The evidence of spirit liberation is questionable. Is there any measurable difference between blessed families that have liberated all their ancestors and those who have not?

II. Systematic Perspective: CP Works as “Spiritual Healing”

Based on the anecdotal evidence of testimonials by CP retreat participants (n=1,847) collected between July 2001 to October 2018, three major types of healing are identified:

- (1) healing from physical ailments (~5%);
- (2) resolution of social conflicts and emotional trauma (~15%);
- (3) experiences of transformation and spiritual growth (~80%).

Due to the broadness of the CP experience, this paper argues to use the notion of “spiritual healing” as an analytical category.

“Spiritual healing” involves non-physical forces that are beyond direct access by means of empirical science. These forces are not specifically presumed to be theistic only and may involve other notions of spiritual entities or powers, for example, angels or spirits.

But how can CP-style spiritual healing and a scientific outlook be reconciled? The paper discusses this problem in further detail.

III. Future Perspective: Three Scenarios

There are three basic scenarios for the further development of the CP Providence:

- (1) **Fundamentalist Scenario:** A literal interpretation of spirit liberations will likely lead to a schism that could be likened to the Protestant Reformation.
- (2) **Conservative Scenario:** Less focus on ancestor liberation, more emphasis on other forms of spiritual practice.
- (3) **Reformative Scenario:** A shift from literal to metaphorical interpretation of CP works. Theological innovation will lead to a holistic approach to spirituality that is in tune with science.

Concluding Remarks

Interpreting the CP Providence in terms of spiritual healing opens up innovative theoretical perspectives with practical implications. To better understand the scope of spiritual healing at CP and develop a reformed, holistic model more research is required.

- First, the efficacy of the CP works could be assessed by means of quantitative and qualitative studies among staff and attendants of CP retreats.
- Second, international collaboration with Unificationists working in health-related professions will improve CP's public profile.
- Third, it is recommended to set up an interdisciplinary team that is able to harmonize religious, scientific, medical, and psychological approaches as one united undertaking.

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A complaint on the use of AI in home church services

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1. Introduction

The development of artificial intelligence will have a huge impact on worship, church education, and pastoral counseling. If the church fails to respond to these AI challenges, the church will decline. However, if the church prepares for the era of artificial intelligence, AI will support effective and high-quality pastoral activities. Artificial intelligence could be a crisis for the church or a new opportunity.

With the development of artificial intelligence, people's level of knowledge and information has been leveled. Therefore, it will be a layman-centered pastoral activity with increased freedom and autonomy of laypeople in pastoral activities such as worship, education, and counseling. Humanoid robots will be able to lead worship, education,

2. raising/alternative/conclusion

Raising the question

Theology is called a guide and watchman who guides the church. It responds to the challenges of the ideology, culture, and consciousness of the times of the time, and plays a role in guiding the church on the way out. In this era, the AI technological civilization is a serious challenge to the church. AI technological civilization changes people's consciousness and lifestyle. In these times of change, if the church does not respond properly and does not grasp people's consciousness, the identity and existence of the church itself will inevitably be shaken. However, when using AI devices by churches, the following points should be considered.

First, it is a problem of accepting people and properties appearing in virtual space as reality. The person appearing in the virtual space is not an entity. It is a question of whether it is possible to worship a person appearing in an image or virtual space.

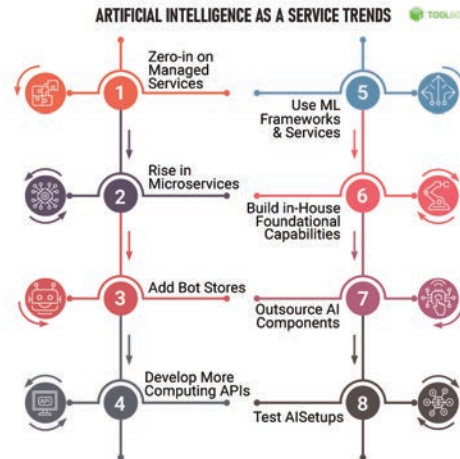
Second, the question of whether a virtual space can be viewed as a sacred space arises. The question of whether a sacred space can break the existing idea of a gendered place or object.



10 Practical Ways to Use AI in Your Church

AI is here to stay. It's very much like the dawn of computer era in the 80s and 90s. Or the rise of the internet era in the 2000s. It's not going anywhere. It's only going to get better. It's only going to get more integrated into our lives.

Upcoming Artificial Intelligence as a Service Trends



With growing competition across industries, businesses are increasingly investing in digital technologies such as AI to gain a competitive edge over their competitors. As such, AIaaS trends are set to take center stage in the cloud computing world. Let's look into the top eight AIaaS trends to watch out for in 2021.

Although family churches have many advantages and pure functions, they have their limitations. Since there is no dedicated pastor, there will be limitations such as preaching, education, counseling, friendship, etc. AI can greatly contribute to overcoming these limitations of family churches. In particular, AI will be able to act as a pastor in a family church service that must be given centered on the lay without a dedicated pastor.

3. Conclusions

It is predicted that the future church will be a family church. Based on the current consciousness and lifestyle of people, the future church has no choice but to go to a family church. Family churches are groups that can most efficiently use AI devices due to the nature and nature of churches. If AI devices are used in worship, education, and communication, the community, artistry, and spirituality of worship can be further strengthened. However, there are limitations to the independent use of AI devices by family churches. Therefore, the local church, which serves as the regional headquarters, should support the family church by acting as a platform.

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To investigate the impact of the Social Innovation on Youth Transitioning to Adulthood in Zambia

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Introduction

▪ Background

- Social Innovation can be referred to as the process addressing societal challenges through coming up and implementing new ideas, products, or services while also improving the overall well-being of individuals and communities (OECD, 2024; Mulgan G et al, 2007).
- Some of these social innovations may include education, healthcare, environmental sustainability, poverty reduction and more.
- The government of Zambia in collaborations with other stakeholders introduced various initiative to improve the wellbeing of the local community of Zambia which include Social Cash Transfer and Youth Empowerment Fund.

▪ Objectives

❖ General Objective

- ✓ To investigate the impact of the social innovation on youth transitioning to adulthood in Zambia.

❖ Specific Objective

- ✓ To investigate the impact of the Youth Empowerment Fund on the wellbeing of youths in Zambia
- ✓ To understand the effect of social cash transfer on the general population in Zambia.

Research Methods / Findings

❖ Methodology

- ✓ The descriptive and cross sectional research designs were used collect information from the respondents.
- ✓ Randomly selected 500 youths aged between 15 and 34 years of age to answer the questionnaire on the first objective.
- ✓ While 300 respondents aged between 15 to 70 years were randomly selected for oral interviews on the second objective

❖ Discussion and Findings

- ✓ The research results showed that 42% of the respondents benefited from the Youth Empowerment Fund program stating various reasons which included improving on their social skills, business financing, behaviour, employment opportunities, academic accomplishment and self-esteem.

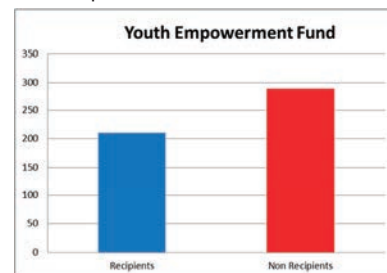


Fig. 1. Youth Empowerment Fund

- ✓ While 33% of the respondents found the social cash transfer program to be beneficial in ways such as financial capital, increased food security, improved wellbeing of the children, improved living conditions, etc.

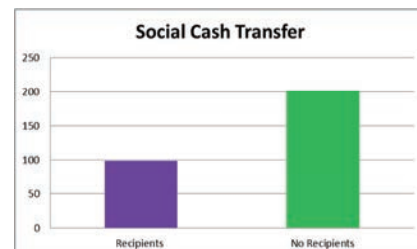


Fig. 2. Social Cash Transfer

Conclusions

- ✓ Social innovation offers a broad approach recognizing the interdependence of various factors and stakeholders in the wellbeing of the community rather than just focus on social enterprising, business engagement and philanthropy which is a narrow way of looking at it.
- ✓ According the research results, it was found that these social innovations did not cover a lot of the youths, poor and vulnerable groups of the society even though it has potential to empower more people.



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Automatic control system for light transmittance of tinting

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Introduction

- Background: Feeling uncomfortable because the light transmittance of the tinting cannot be adjusted according to changes in the brightness of the external light source.
- Objective: Maintaining a constant amount of light transmission by automatically controlling the density of tinting in response to disturbances to maintain a constant internal illuminance set by the user
- Significance of the work: It can automatically control the light transmittance of the window to maintain a comfortable vehicle interior environment, and when applied to the windshield, it can protect the driver's vision by responding to strong light suddenly applied.

Experimental / Methods / Results

The operating principle of the polarizing film in the project product is as Fig. 1. Light inherently disperses in multiple directions; however, when it passes through a polarizing film, it is aligned in a single direction. By utilizing two polarizing films, the transmittance of light can be controlled, thereby adjusting the interior brightness.⁽¹⁾

By using the polarizing property of Polaroid film, the light transmittance of the window can be adjusted by controlling the relative angle difference between the two films as Fig. 2. In order to automatically control this in response to disturbance, an illuminance sensor is attached internally. When the illuminance value received by the sensor becomes greater than the illuminance range set by the user, the light transmittance is reduced by increasing the relative angle difference between the two films, and the sensor illuminance exceeds the set illuminance range. As the received illuminance value decreases, the difference in the relative angles of the two films is reduced to increase light transmittance to keep the internal illuminance constant.⁽²⁾

Due to the nature of the CDS illuminance sensor, the measured voltage value does not increase linearly, but takes the form of a log graph where the value increases rapidly in low illuminance sections and increases slightly in high illuminance sections, making it difficult to determine the section.

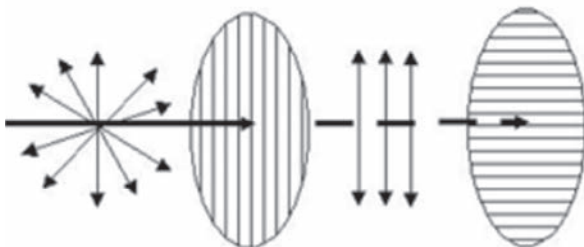


Fig. 1. Polarization film's principle.

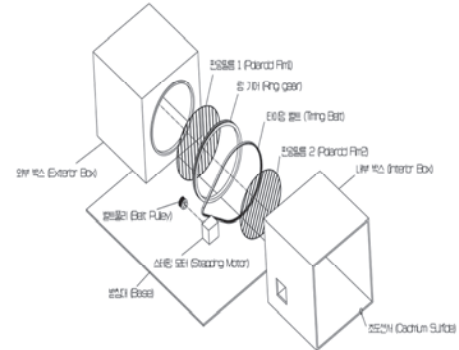


Fig. 2. Tilting hardware system.



Fig. 3. Tilting system operation results.

Conclusions

Using an illumination sensor, we succeeded in constructing a feedback system that maintains internal illuminance within a certain range in response to changes in external brightness as Fig. 3.

The desired internal illuminance level was configured so that the user could set it in 10 levels, and each range was successful.

Considering the case where the light is suddenly turned on from the other side of the vehicle, the brightness of the external LED is increased to the maximum at once, and the window transmittance is adjusted accordingly within 2 seconds.

Accordingly, if PDLC film is used instead of Polaroid film, there are no restrictions on the shape and the time it takes to adjust the window transmittance is shortened, which significantly lowers the accident rate due to sudden light from the other vehicle and excessive tinting on the road at night, especially when used on the front window of a vehicle.

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A High-Resolution CMOS Voltage Reference Design in Battery System

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- Large voltage fluctuations in battery cells can cause control system errors, increasing the risk of operational instability and potential fires.

Introduction

- To manage Voltage fluctuations, a Voltage reference signal with high analytical power should support accurate battery cell measurement.

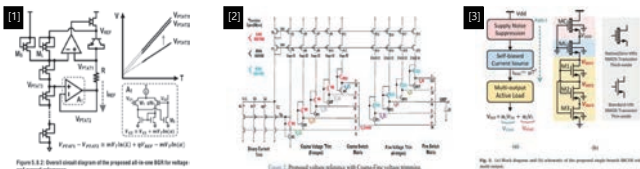


Fig 1. Block Diagram of Existing Technology

Experimental / Methods / Results

- The proposed 256 PMOS TR bank-based Vref generator uses a 4-to-16bit decoder for efficient voltage trimming, offering low power consumption, better noise margins, and simpler power-on behavior

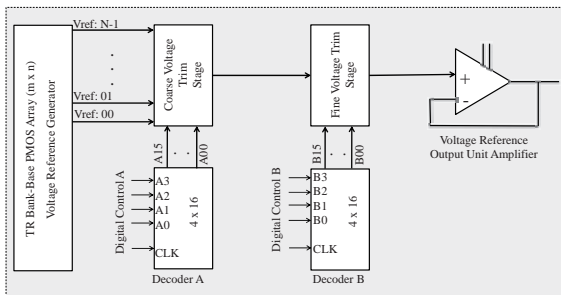


Fig 2. Block diagram of the proposed High-Resolution Vref.

- The coarse and fine decoder obtains a wide voltage reference range and precise output.

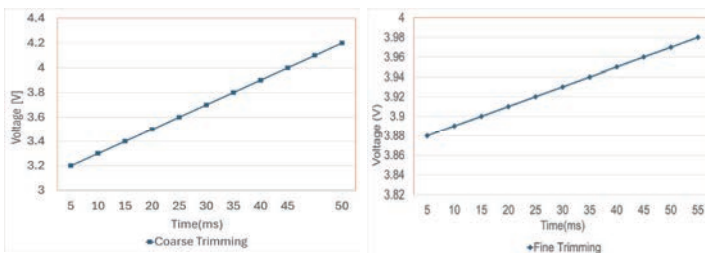


Fig 3. Simulation of Coarse/Fine Trimming Vref Results.

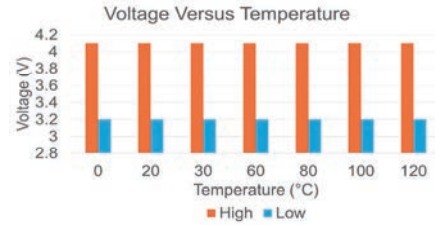
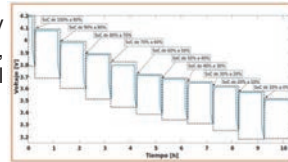


Fig 4. Vref achieves a temperature coefficient of 56.3 ppm / ° C

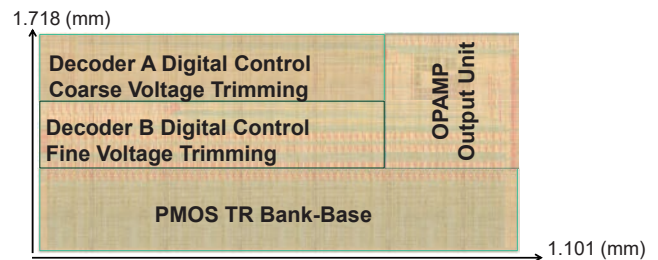


Fig 5. Chip Layout (size : 1.718 mm x 1.101=1.8mm²)

Table 1. Comparison with existing technology

Parameter	[1]	[2]	[3]	This work
Technology(nm)	180nm	180nm	180nm	180nm
Temperature range (°C)	0 to 110	-10 to 110	0 to 120	-10 to 120
Voltage Supply	-	1	0.45	5
*Vref output Range	1.228 V	86 ~ 536 mV	-	3.3 ~ 4.2 V
*Vref Resolution	Fixed	16 mV	200.4mV	3.5mV
Power consumption	0.0093 (μW)	0.00135 (μW)	0.000067 (μW)	68 (μW)
Area (mm ²)	0.055	0.002	25.23	1.8

*Vref: Voltage Reference.

*Iref: Current Reference.

*TR: Transistor

Conclusions

- The research presents a high-resolution CMOS voltage reference using a TR bank with a decoder for coarse trimming, generating 3.2V to 4.2V in 16 steps, with fine trimming at 5mV resolution. It consumes 68μW and occupies 1.8mm², with a temperature coefficient of 56.3 ppm / ° C at (3.2 ~ 4.1V). This device offers a broad voltage range and precise output for temperature compensation.

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Anti-cancer activity of *Echium amoenum* on AGS gastric cancer cells

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Introduction

Gastric cancer (GC) is the fifth most common cancer worldwide. Since GC usually does not cause early symptoms, it is difficult to diagnose until it has invaded other organs of the body and leads to metastasis. Therefore, prevention and treatment of the GC have become important issue for the patients.

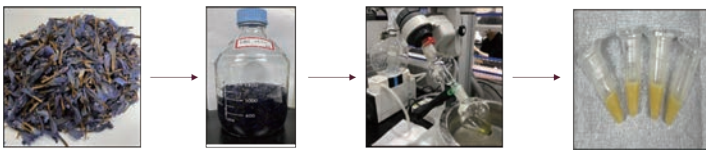


Echium amoenum is a traditional medicinal plant belonging to the Boraginaceae family. Recently, in several studies, the anti-cancer effect of *Echium amoenum* has been reported. However, there has been no research about ethyl acetate extract of *E. amoenum* (EAEC) on gastric cancer AGS cells. Thus, we demonstrated for the first time the anti-cancer and anti-metastasis activity of *E. amoenum* against AGS cells.



Method and Results

To extract *E. amoenum*, 10 g of *E. amoenum* was soaked in 500 mL of ethyl acetate, stirred at room temperature for 24 hours, filtered once, centrifuged, and then filtered the supernatant. The extract was concentrated, stored at -70 °C, and then lyophilized at -110 °C for 5 days. EAEC was made into a stock using DMSO.



Anti-cancer effect of EAEC on GC

Fig. 1. Effect of EAEC on the proliferation and colony formation of AGS cells.

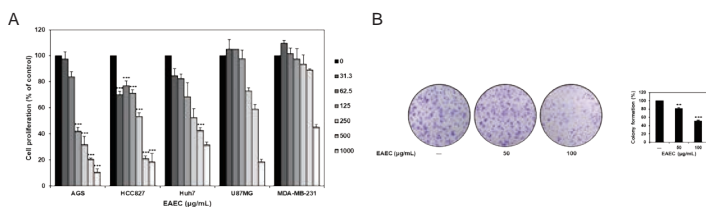


Fig. 2. Effect of EAEC on inducing cell cycle arrest at G2/M and S phase and apoptotic cell death of AGS cells.

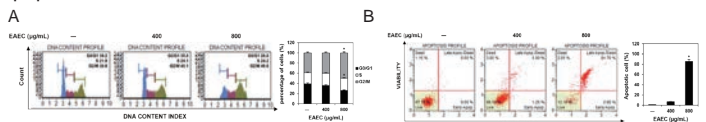
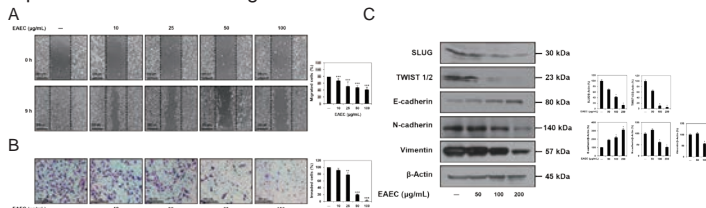


Fig. 3. Effect of EAEC on the migration, invasion of AGS cells, and the protein expression level of EMT regulators.



Anti-cancer effect of RA on GC

Fig. 4. Analysis the active ingredient of EAEC using HPLC and LC/MS .

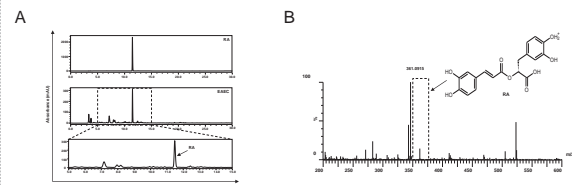


Fig. 5. Effect of RA on the proliferation of AGS cells by inducing cell cycle arrest at S phase and apoptotic cell death.

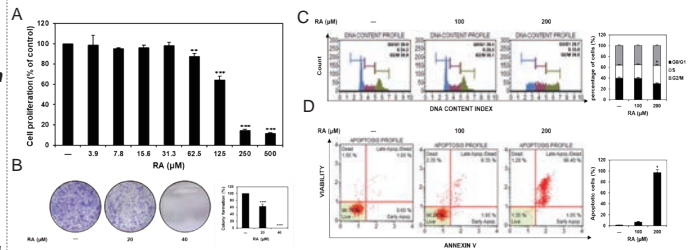
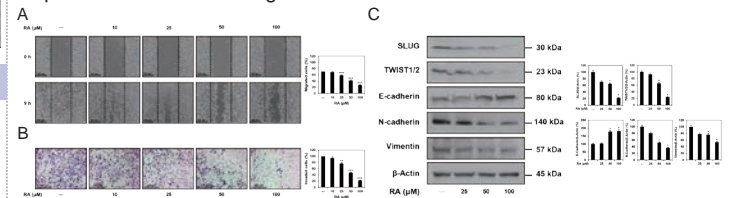


Fig. 6. Effect of RA on the migration, invasion of AGS cells, and the protein expression level of EMT regulators.



Conclusions

This study suggests that EAEC and RA inhibit cell proliferation and colony formation ability by inducing apoptosis and the cell cycle arrest of the AGS cells. In addition, EAEC and RA significantly suppressed the migration and invasive abilities of cells, suggesting that EAEC and RA inhibit the metastatic ability of AGS cells. In particular, the anti-cancer activity of EAEC and RA against AGS cells was associated with the regulation of the EMT markers including E-cadherin, N-cadherin, Vimentin and the upstream pathway including SLUG and TWIST1/2. In conclusion, EAEC and RA, have the potential to be used as anti-cancer drugs and anti-metastatic treatments on GC.

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Disaster Management and Safety Culture Promotion Strategies: An Analysis of the Effectiveness of SNS Campaigns

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Introduction

- In recent years, the frequency of natural and man-made disasters has rapidly increased, leading to human casualties and property losses.
- This study aims to highlight the importance of promoting a safety culture and to analyze the effectiveness of various promotional methods to propose more effective strategies for spreading safety culture.
- Specifically, it focuses on analyzing the effectiveness of using SNS to quickly disseminate information and encourage citizen participation in safety practices.
- The study analyzes cases like the Gyeongsangnam-do Safety Experience Fair, Jeju Special Self-Governing Province's Safety Culture Movement, and Gimpo City's efforts to ensure citizen safety to derive successful promotional strategies.
- Additionally, it evaluates the pros and cons of SNS campaigns like the ThanksToChallenge to explore future development directions.

Experimental / Methods / Results

- This study reviewed literature and analyzed cases to understand the importance of safety culture and derive effective promotional strategies.
- It evaluated cases like the Gyeongsangnam-do Safety Experience Fair, Jeju Special Self-Governing Province's Safety Culture Movement, Gimpo City's citizen safety efforts, and the ThanksToChallenge campaign, focusing on the effectiveness of public campaigns using SNS.

Table 1. Major Cases Analyzed and Their Characteristics

Case	Characteristics	Main Activities
Gyeongsangnam-do Safety Fair	Enhancing residents' autonomous response ability	Safety education programs, experience activities
Jeju Special Self-Governing Province's Safety Culture Movement	Encouraging resident participation, establishing a safety culture	Safety inspections, promotional campaigns
Gimpo City's Citizen Safety Efforts	Establishing a citizen-centric safety culture	CCTV integration, disaster situation room
ThanksToChallenge Campaign	Encouraging participation, improving safety awareness	Expressing gratitude to healthcare workers, public participation campaign

Results

- Each case effectively highlighted the importance of safety culture and demonstrated effective methods for its establishment.
- Public campaigns via SNS were particularly effective in rapidly disseminating information and encouraging active citizen participation. The Gyeongsangnam-do Safety Experience Fair enhanced residents' autonomous response abilities and expanded safety infrastructure.
- Jeju Special Self-Governing Province's Safety Culture Movement played a significant role in encouraging resident participation and establishing a safety culture.
- Gimpo City promoted various safety culture activities to establish a citizen-centric safety culture. The
- ThanksToChallenge campaign encouraged widespread participation and contributed to raising safety awareness.

Discussion

- This study confirmed that promoting safety culture using SNS is very effective.
- SNS campaigns can quickly disseminate information and encourage participation from a wide range of people, leading to positive changes in perception.
- Additionally, successful cases were analyzed to suggest various approaches such as tailored education programs, public-private cooperation, and effective promotional strategies.
- These findings provide concrete measures for spreading a safety culture.

Conclusions

- This study emphasized the importance of disaster and safety management and analyzed strategies for promoting safety culture, focusing on the effectiveness of SNS-based public campaigns.
- It reviewed cases such as the Gyeongsangnam-do Safety Experience Fair, Jeju Special Self-Governing Province's Safety Culture Movement, Gimpo City's Citizen Safety Efforts, and the ThanksToChallenge campaign.
- These cases highlighted various approaches to spreading safety culture. Continuous education and training, strengthened public-private cooperation, and effective promotional strategies are necessary for spreading safety culture.
- Future research should analyze various regional cases and assess long-term effects. Additionally, developing more effective promotional strategies using the latest technologies is essential.

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Implications of a Fast-Feedback Linear Response Model of Radiative Forcing Induced Climate Change

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Introduction

- Observations show that Earth's global mean surface temperature (GMST) has increased 1.2°C over that of the pre-industrial era [1],[2].
- Applying fast-feedback amplification that reproduces ice-age temperature variations [3] and an ocean-response function that reproduces ocean-atmosphere simulations [4] of GMST upon CO₂ doubling, successfully reproduces a smoothed GMST behavior.
- It is found that forcing is a "half-now, half-later" proposition, so a "net-zero" policy can only slow global warming, not stop it. The full paper presentation will be given Saturday 10am in the WRIST session.

Experimental / Methods / Results

The equation for radiative balance at temperature T at the Earth's surface is

$$\varepsilon\sigma T^4 = S(1 - \alpha) \quad (1)$$

where σ is Stefan-Boltzmann's constant, S is one-fourth the solar constant, α is the albedo, and ε is the emissivity of Earth which is 0.616 when T is 288 K. Perturbing (1) by adding a forcing $\Delta F = \sum f$ to the right hand side, where each f is a separate contribution like CO₂, land-use or aerosols (see Fig. 1) "forces" the temperature to shift by

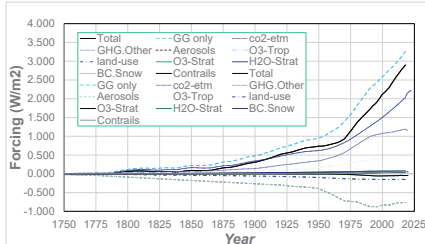


Fig. 1. Contributions f to climate forcing [5]

the GMST ΔT away from T . Plugging in numbers yields

$$\Delta T \approx 0.303 \sum f \text{ K}/(\text{W}/\text{m}^2) \quad (2)$$

This represents a "bare forcing" model having "no-feedback" and "no ocean inertia" [6] where these important climate effects are ignored. Simulations reveal that effects of the oceans' thermal inertia on a CO₂ doubling "pulse" can be represented as a "response" function (Fig. 2).

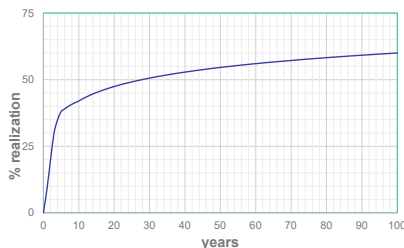


Fig. 2. Response to CO₂ doubling approximating results found in ocean-atmosphere simulations [4].

Also, a net fast-feedback of 0.75 °C/(W/m²) was found to reproduce ice-age temperature time series when added to slow albedo feedbacks of changing ice-sheets [3]. When these are combined equation (2) becomes

$$\Delta T \approx 0.303\text{K}/(\text{W}/\text{m}^2) \times 2.47 \int_{t_0}^t R(t-t')dF(t') \quad (3)$$

Where the factor 2.47 is the fast-feedback amplification factor. Thus, increments $dF(t')$ added to the atmosphere at a time $t' < t$ (i.e., earlier than t) are delayed and contribute later at time t according to the fractional response R , until 100% of each forcing increment is added over time. The result is plotted in Fig. 3 below together with thermometric and satellite observations.

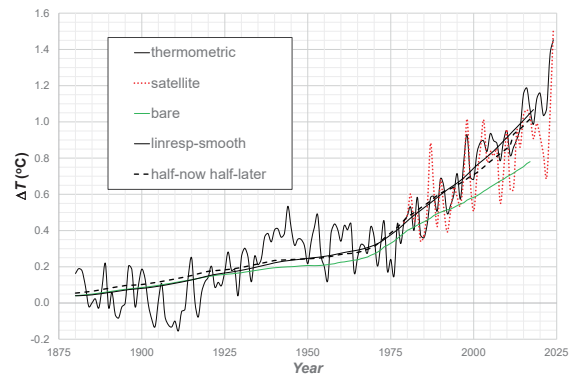


Fig. 3. The Fast-feedback Linear Response model is "linresp-smooth". For simplicity solar and volcanic forcings are excluded. "bare" is the no-feedback no thermal inertia model.

The "half-now, half-later" model is the bare model multiplied by the fast-feedback amplifier and a factor of one-half, as the response function suggests a step-function "half-now" behavior.

Conclusions

A simple analytical model of forcing amplified by fast-feedbacks modified by ocean response inferred from simulation produced excellent results that reproduce observed time series of the GMST. The close agreement of a "half-now half-later" model implies that **even under "net-zero" policy, the GMST will still rise slowly, nearly doubling** due to oceans gradually disgorging their stored heat **over the following centuries.**

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A proposal to develop the repetitive restoring technology of rolling bearings to realize the goal of circular economy and the sustainable development

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Introduction

- The motivation behind this proposal is driven by the quest to enhance the fatigue life of rolling bearings and restore the fatigue life of remanufactured bearings using innovative surface modification technologies such as Ultrasonic Nanocrystal Surface Modification (UNSM). The focus is not only on improving the efficiency and effectiveness of these technologies but also on exploring deeper into their scientific underpinnings to optimize their outcomes. Additionally, there is a drive towards advancing circular economy principles by enabling the repetitive reuse of remanufactured bearings. Current technology allows for only one additional reuse, but the challenge is to exceed this limitation and achieve more than three times the reuse through the application of innovative surface modification techniques, pushing the boundaries of knowledge and technology, ultimately contributing to more sustainable and efficient industrial practices for a circular economy.

Restoring technology

UNSM technology

- Ultrasonic Nanocrystal Surface Modification (UNSM) is a surface modification/treatment technology that causes surface severe plastic deformation (S²PD) at the surface region to generate a gradient nanostructured surface layer along with a modified surface. The process utilizes an ultrasonic vibration superimposed on a combination of static and dynamic loads to induce high-strain-rate plastic deformation on a material surface. UNSM technology is an effective and economical method to generate a gradient nanostructured surface and to modify the surface of metallic materials by refining the coarse grains into nano-grains.

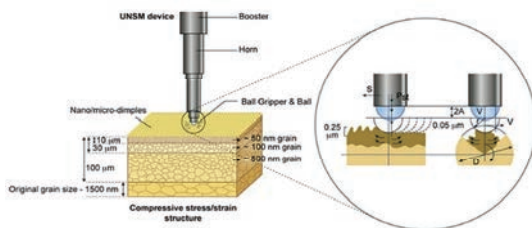


Fig. 1. Schematic of UNSM technology

- Formation of an innovative surface by UNSM technology and effects
 - high pressure < 30 GPa onto the surface makes severe elastic and plastic deformation at the surface layer
 - high and deep compressive residual stress (higher than 1 GPa into depths > 1 mm)
 - micro-dimpled (textured/patterned) surface
 - increase in mechanical properties (hardness, strength)
 - nanostructured surface layer (nano-grains > 50 nm; effective depth > 200 μm)

Restoration of used rolling bearings and enhancing fatigue life of new and remanufactured bearings by UNSM technology

UNSM + Remanufacturing of Industrial Rolling Bearings: Enhancing Service Life more than New One's

Comparison of Bearing Fatigue Life Test
 - New Bearing + UNSM: more than 1.5 times to New one's
 - UNSM on Remanufacturing Bearings: 1.07 times to New one's

Reverse aging in life science

	Time (h)	Cycles to failure	Ratio [%]
*1: New Bearing	53:47	6.454×10 ⁶	100.0
UNSM-treated on *1	83:24	1×10 ⁷ ~ run out	155.0 ↑
*2: Polishing after 100% used Bearing	29:26	3.532×10 ⁶	45.0
UNSM-treated on *2	57:37	6.915×10 ⁶	107.1

2.9 Giga Pascal, Dynamic Load Rating(255kN), 2008PM



UNSM treatment of inner (a) and outer (b) raceways

Spherical Roller Bearings for Continuous Casting

SKF 22204-110-CA, 22204-110-CA, 22204-110-CA



Remanufacturing of Big Size Bearings - Steel Industry, Cement Industry-

Fig. 2. Bearing fatigue life

Originality and Innovation

- This is a total solution that includes a fundamental scientific background and the development of a numerical simulation model to design optimal surface modification for Fatigue Restoration and Life Extension of Bearings. As a result, it is the first implementation of 3 times remanufacturing bearings in circular chains for UN SDGs and EU CE as shown in Fig. 3.

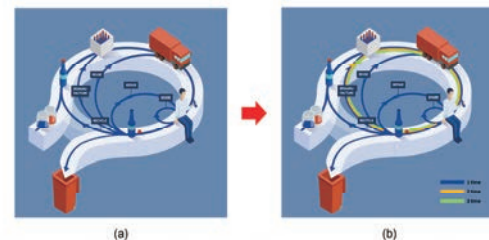


Fig. 3. Current Circular Supply Chain average one-time reuse after remanufacturing (a) and New Circular Supply Chain Expectation: Average three more times reuse after UNSM total solution (b).

Conclusions

Reaching beyond the state of the art, the objectives of this proposal are:

- To develop a fundamental scientific background and multi-scale simulation model to design optimum surface modification technology and parameters for Fatigue Life Restoration and Extension of Bearings
- To develop an Innovative Surface Modification System for implementation on real ball and/or roller bearings for industrial application testing. The developed system satisfies a green manufacturing approach

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A proposal to develop a mitigation technology of corrosion and stress corrosion cracking of Molten Salt Reactor vessel

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Introduction

- The ultimate goal of this proposal is to significantly enhance the corrosion resistance of main components in chloride-based Molten Salt Reactors (MSRs), a promising new technology among Small Modular Reactors (SMRs) crucial for advancing energy solutions and achieving carbon neutrality. By emphasizing the application of advanced cladding layers on 316 stainless steel, we address general corrosion, Stress Corrosion Cracking (SCC), and chromium depletion at operating temperatures ranging from 500° C to 700° C using commercial nickel, Alloy 625, and innovative MoNiCr alloy. Employing advanced surface modification techniques such as Ultrasonic Nanocrystal Surface Modification (UNSM), this project seeks to make compressive residual stress and nano grains to enhance resistance to corrosion and stress corrosion cracking. The main objective includes producing a state-of-the-art mockup vessel for an MSR, designed to endure the severe conditions of chloride molten salt environments at 650° C and 4-5 bar pressure, with an ambitious 20-year lifespan.

Molten Salt Reactor

- A molten salt reactor converts heat to electricity, but in this case the fuel does not come in the form of solid pellets. Instead, the fuel is dissolved into a liquid salt mixture, at high temperature (450-750°C). The energy from the splitting of uranium atoms is used to directly heat up the molten salt. The hot salt is then used to boil water for electricity, or to deliver the heat to nearby industrial processes. Immediate benefit of this is a higher efficiency of electricity production. In addition, the reactor is operated at much lower pressure than Nuclear Power Plants which improves safety and reduces costs.

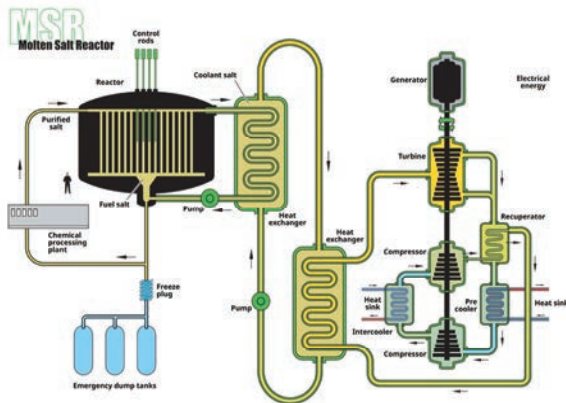


Fig. 1. Schematic of MSR

- MSR is one of the easiest reactor types to miniaturize and modularize because it can integrate coolant and nuclear fuel. It will emerge as the center of various SMR markets in the future. Due to the above characteristics, it is evaluated as one of the most suitable technologies for polar, ocean, space, and military base reactors.

MSR's Corrosion Environment and Mitigation Technology

- MSR operates in a very strong corrosive environment, and most of the current commercial high-temperature materials are seriously damaged by corrosion. In order to develop a successful MSR, it is essential to develop technology to improve the corrosion resistance of materials and components that can ensure safety during the operation period.

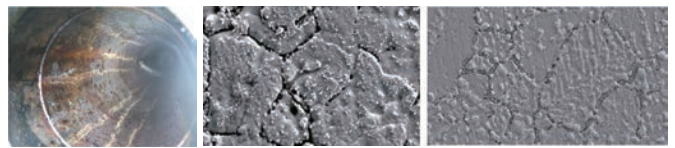


Fig. 2. Case of surface corrosion caused by molten chloride

- Approved "ASME Code Case N-931: Performance and Qualification Criteria for Mitigation of Stress Corrosion Cracking by Surface Stress Improvement Section III, Division 1; Section III, Division 3" will be utilized to mitigate corrosion and SCC as shown below.

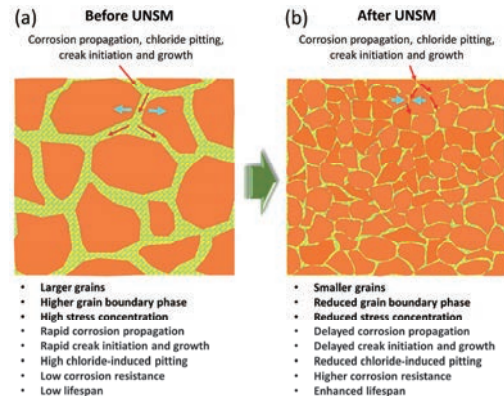


Fig. 3. Schematic of UNSM's effectiveness mechanism on corrosion and chloride propagation, crack initiation and growth reduction

Conclusions

- As shown in the figure above, we aim to develop a technology to improve the corrosion resistance of core parts of MSR by utilizing the surface stress improvement technology.

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Thoughts on the eschatological Messiah and the personal Messiah

- Focusing on the Family Federation for World Peace and Unification

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1. Introduction

A typical messiah is an eschatological figure, referring to a human who has inherited the omnipotent power of the Creator God or a deity incarnated as a human. They are often claimed to have manifested on earth with the mission of saving humanity. Conversely, a personal messiah is someone who regards the eschatological messiah as their own object of faith. In such cases, the messiah is often recognized not as a human but as a flawless, perfect being, essentially a deity.

An eschatological messiah initially emphasizes the greater value of saving humanity over individual salvation. However, it is common for followers to accept the messiah's grand vision but increasingly view him as a figure for their own safety and happiness. This often leads to the messiah's role being limited to personal faith, elevating him to an omnipotent deity as an individual object of worship.

Therefore, this study aims to explore the nature of the messiah within the Family Federation by distinguishing between the eschatological messiah and the personal messiah. Additionally, it seeks to contribute to the establishment of the faith attitudes among Family Federation members.

2. Concept of the Messiah

1) Eschatological Messiah

The eschatological messiah refers to the incarnation of God to save humanity from chaos. In Christianity, this concept began with the appearance of Jesus Christ during the persecution of the Israelites by the Romans. Jesus Christ demonstrated his role as the eschatological messiah by proclaiming his mission to save not only the persecuted Jewish people but all of humanity. In Korea, during periods of turmoil such as Japanese colonial rule, liberation, and the Korean War, several eschatological messiahs emerged, attempting to save the suffering people who had lost hope. Among these, one of the most prominent messiahs is Reverend Sun Myung Moon, the founder of the Family Federation.

2) Personal Messiah

A messiah who appears with a divine revelation to save humanity from suffering primarily aims to bring happiness to individuals. Consequently, those who encounter the messiah hope to find happiness through him and wish for the messiah to possess omnipotent abilities. These personal hopes can elevate a human messiah to the status of a deity. This deification of religious founders often leads to the original positive intentions of the religion being lost, resulting in the religion being labeled as a cult and eventually marginalized in society.

A personal messiah can refer to a religious founder, but it can also be a deeply human figure who saves someone from the many difficulties encountered in life. For instance, if someone helps you overcome a life-threatening situation, that person becomes your personal messiah.

3) The Messiah of the Family Federation

The Messiah of the Family Federation is embodied by the True Parents, who are tasked with actualizing the will of the Creator God. Members who practice the teachings of the True Parents in their families, tribes, and communities are also considered small messiahs. The Family Federation's Messiah emphasizes the salvation of humanity as a whole over individual salvation. Since its inception, it has focused on holistic evangelism through NGO organizations like the International Federation for Victory Over Communism. Therefore, the goal of the Family Federation's Messiah is to extend from individual salvation to becoming the Messiah of families, tribes, societies, nations, and ultimately, all humanity.

3. Conclusions

A messiah who founds a religion with the intention of saving humanity is considered an eschatological messiah. However, even an eschatological messiah can become a personal messiah if one believes in and follows them as an object of faith and conviction. Today's prosperity-oriented faith can be seen as a transformed form of faith, focusing more on personal happiness rather than the grand purpose of the eschatological messiah for humanity.

In the Family Federation, the messiah, True Parents, convey the will of Heavenly Parent to humanity and realize it on earth, leading people to a world of happiness. In this process of guiding humanity, numerous small messiahs have emerged, and when all of humanity becomes small messiahs, the Kingdom of Heaven on earth can be achieved. Thus, fulfilling my mission as a small messiah means walking alongside the True Parents, the eschatological messiah, and it is not merely a condition for my own entry into heaven.

The founders of the Family Federation for World Peace and Unification, known as the True Parents, came as the eschatological messiahs for humanity and faithfully fulfilled their messianic role for the happiness of humankind. However, some members distort the True Parents' teachings, limiting them to objects of faith for their personal happiness, thus reducing them to personal messiahs. This devalues the True Parents' universal mission. The true value of the Family Federation can only be realized when the True Parents are recognized as the messiahs for all humanity.

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A Study on the of Adverbial Investigation Errors by English-speaking, Chinese-speaking and Japanese-speaking Koreans Learners -Future research: Vietnamese-speaking and Russian-speaking Korean Learners -

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Introduction

- This study aims to analyze the errors that Korean learners make in using the investigative '-e' and the types of errors by language group. In particular, we will systematically examine the difficulties that learners encounter, focusing on the different meanings and functions of "-e" and the patterns of errors. Through this study, we will draw implications for grammar education and suggest effective teaching directions.
 - This study aims to analyze the "Korean Language Learner Corpus" of the 「National Institute of the Korean Language」, and to draw more comprehensive results by utilizing data collected from various educational institutions.
- How does Korean learners' use of the investigative '-e' vary depending on the grammatical system of the language.
 - How do the types or errors in '-e' vary depending on the grammatical system of the language.
 - How do semantic errors in research '-e' look like.

Subjects of analysis

- The research subjects are corpora of learners whose native language are English, Chinese, Japanese, Vietnamese and Russian.
- Analyze the error, including not only the incorrect use of the investigation '-e' but also the use of other investigations where '-e' should have been used.

Analysis procedures

1. Error determination: We applied four criteria to minimize the subjectivity of error determination.

- Only errors with the adverbial investigation '-e' are analysed, excluding other grammatical error.
- Semantically and morphologically complete sentences are not subject to error analysis.
- Omitting an investigation is not considered an error.
- It judges every incorrect sentence as an error, without considering the learner's stage of learning.

2. Error type classification: We categorize them into Usage errors(UP error) and Target error(TP error). The subtypes are categorized into morphological errors, semantic errors, and other errors.

3. Analysis of the linguistic characteristics of each Language Group: Organize the language system features of each language by sentence word order and affix order. Then, language with similar language systems are grouped together and analyzed.

4. Semantic analysis of particles: categorized the meaning of investigations based on the usage of investigations presented in 「Korean Grammar for Foreigners」 and 「Korean Grammar for Education」.

5. Calculation of usage and error rates': Usage rate(%) of '-e' = (frequency of specific meaning of '-e'/total frequency of postposition used)*100, UP error rate(%) = (number of UP errors/number of UP usages)*100, TP errors rate(%) = (number of TP errors/number of TP usages + number of TP errors)*100

Analysis results

Table 1. Usage rate of the particle '-에' according to its meaning

Existence locaton	Time	Target	Destination	Standard of comparison
9.10% (457)	4.24% (213)	3.08% (155)	2.94% (148)	1.05% (53)
Reason Cause	Idiomatic Expression	Unit	Instrument Means	Total '-에'
0.69% (35)	0.61% (31)	0.55% (28)	0.48% (25)	22.82% (1,145)

→ Korean Learners perceived and used '-e' primarily as a Location of existence.

Fig. 1. Usage rates of different meaning od '-에' by Language background



→ In Chinese-speaking, the use of '-e' for Target is higher than for Destinations, due to the varied usage of Chinese prepositions '到, 从, 对'.

→ The Japanese-speaking particles 'に, へ, で' are used in various meanings, resulting in relatively small differences in usage rates for each meaning.

Conclusions

- Confirmed that Korean '-e' does not correspond 1:1 with Japanese and Chinese articles.
- We emphasized the need to clarify and teach the meaning of investigation in Korean education.
- Lack of cross-linguistic analysis to understand usage patterns and causes by language region.
- Future research will analyze the usage and error rates of Vietnamese and Russian-speaking learners to identify common semantic errors and language-specific characteristics.

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Lifelong education of Cheon Il Guk Citizens in the Cheon Il Guk Era from the Perspective of Lifelong Education

Chae Soo, Ha (Pre-Director Continuing Education Center of Sun Moon Univ.) csha9353@hanmail.net

Introduction

- Lifelong education is becoming increasingly prevalent worldwide, including in Korea, and is being further reinforced in developed nations. The three fundamental elements of Cheon Il Guk are territory, people, and sovereignty. It is crucial to systematically organize education for the citizens of Cheon Il Guk. Given that the education received by adults who have completed formal schooling constitutes lifelong education, it is essential to structure and systematize the educational content that the citizens of Cheon Il Guk should receive from a lifelong learning perspective.
- Lifelong learning is a vital tool for enhancing individual quality of life and promoting social development. Through lifelong learning, individuals have the opportunity to continuously learn, grow, and contribute effectively to society. It fosters social cohesion and contributes to the development of an enlightened and harmonious society.
- Based on this concept of lifelong education, I would like to outline the basic direction of Cheon Il Guk's lifelong education. In the era of Cheon Il Guk, lifelong education is necessary to strengthen the identity of its citizens, boost their self-esteem, and increase their satisfaction to ensure the success of Vision 2027. It will serve as a motivation to drive the future development of Cheon Il Guk.

The fundamental direction of lifelong education promoted by the government

Government's Strategy for Promoting Lifelong Learning

Promotion of Lifelong Learning by Local Governments, Universities, and Companies: Establishment of local lifelong education governance centered on local governments, with participation from local universities, companies, and related organizations.

Directions for Supporting Lifelong Learning for the 3050 Lifetime Leap

There is a need to diversify lifelong learning pathways by linking various learning experiences across different life areas, such as school and work. While focusing on traditional educational materials, we are also incorporating the latest digital technologies, such as AI, and enhancing online education.

Revising Lifelong Learning Policy

Historically, lifelong learning policies have primarily served to supplement academic abilities or provide leisure activities for those who deviated from the growth path early in life.

It is now time for lifelong learning to become an essential re-education and upskilling policy to help individuals cope with future uncertainties in the era of technological innovation.

Classification of Lifelong Education Programs by the National Institute of Lifelong Education

In South Korea, lifelong education centers classify lifelong education programs into six types: "Civic Participation Education, Culture and Arts Education, Supplementary Education for Academic Ability, Basic Literacy Education, Vocational Competency Education, and Liberal Arts Education." They plan and operate detailed programs based on these classifications.

The fundamental direction of lifelong education in Cheon Il Guk

The purpose of Cheon Il Guk's lifelong education is to instill in individuals a heart of filial piety, enabling them to serve Heaven as true children centered on Heavenly Parents. Additionally, it aims to cultivate a spirit of community among members of the Assemblies of Heavenly Parents and equip individuals with the necessary skills to navigate real-life situations.

To achieve these educational objectives, the goals of Cheon Il Guk's lifelong education can be reasonably stated as follows: nurturing individuals with a heart of filial piety centered on Heavenly Parents, developing citizens of Cheon Il Guk who embody the qualities required of its people, and training professionals to achieve subjectivity.

Cheon Il Guk's Lifelong Education Plan

Since the state's lifelong education model cannot be directly applied to the Cheon Il Guk Lifelong Education Model, I propose a tailored approach based on Cheon Il Guk's educational goals and the aforementioned model. Cheon Il Guk Lifelong Education believes that special education should be added to the national concept of lifelong education by strengthening the perspectives of spiritual education and Cheon Il Guk civic education.

The founding philosophy of Cheon Il Guk Educational Institutions is based on love for God, love for humanity, and love for the nation. Cheon Il Guk's lifelong education is necessary for blessed families who have completed their formal education, from kindergarten to university and graduate studies. The direction of Cheon Il Guk's lifelong education is also grounded in love for God, love for humanity, and love for the nation.

(Table 1) Overview of Cheon Il-guk's Lifelong Education Program

Founding Philosophy of Cheon Il-guk Educational Institute	Continuing Education Program Types Explained	Major Programs	Basic Areas of Lifelong Education in Korea
Character Formation (love for God)	Education to become one with Heavenly Parents and True Parents	True Parents Education Spiritual Program Cheonggyeong Retreat Cheon Il Guk Leader Education	Liberal Arts Education
Cheon Il-guk Citizen Training (love for Humanity)	Heavenly Treasure Crusade and Cheon Il Guk Community Education, Peace Education Cheon Il Guk Language Education	Cheon Il-guk Civic Education Cheon Il Guk Community Education Cheon Il Korean Language and Culture Education	Civic Participation Education
Fostering professionals with subjectivity (love for Nation)	Environmental education, technical education, etc.	Education to improve the quality of life of the people of Cheon Il Guk National Lifelong Education Program Collaborative Education	Vocational Competency Education

Cheon Il-guk Lifelong Education Implementation Agency

Cheon Il-guk Organizations: Family Federation for World Peace and Unification, HJ Heaven and Earth CheonBo Training Center, UPF, Citizen Federation for Unification of Korea, Women's Federation for World Peace, etc.

Cheon Il-guk Educational Institution: Sun Moon University and others.

It is crucial for these institutions to establish governance for the lifelong education of Cheon Il-guk citizens and to develop an operational system for planning, implementation, and evaluation.

Conclusions

The concept of lifelong education should be integrated into the education system for the people of Cheon Il Guk in this new era. This approach will help cultivate the identity of Cheon Il Guk's citizens, enhance their self-esteem, and increase their overall satisfaction, fostering a sense of heavenly purpose.

Furthermore, achieving the Cheon Il Guk Vision 2027 and expanding the Cheon Il Guk era necessitates this educational focus. Lifelong education is essential for creating a world of symbiosis, co-prosperity, and justice, trusted by both leaders and citizens of Cheon Il Guk. More detailed research is required to refine and implement these educational strategies effectively.

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Resource Allocation Scheme for Multihop Cellular Network Using Directional Transmission

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Introduction

- Recently, mobile cellular networks suffer from exponentially increasing data traffic caused by the wide spread use of smart phones and tablets. Moreover, it is foreseen that the amount of mobile traffic will keep increasing exponentially over the coming years. Therefore, to find ways to increase the capacity of wireless systems is important. Multihop relaying and directional transmission are also promising technologies to improve the capacity of mobile cellular network [1].

Resource Allocation Scheme

- In this poster, we propose resource allocation schemes that maximize the capacity of multihop cellular network using directional transmission.

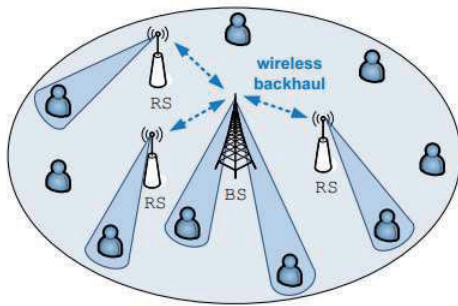


Fig. 1. Topology of multihop cellular networks

- As in Figure 2, we take into proper account the interference between distinct transmission beams directed towards different users which we denote as intra-BS(Base Station)/RS(Relay Station), inter-BS-RS, and inter-RS interferences.

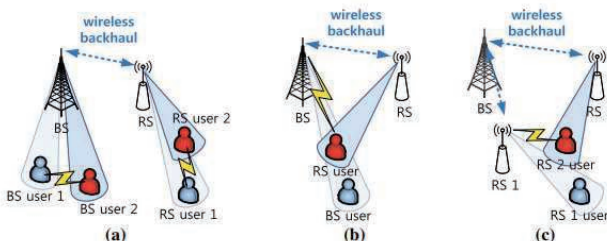


Fig. 2. Interference scenarios (a) inter-BS/RS interference (b) inter-BS-RS interference (c) inter-RS interference

- Figure 3 shows the downlink frame structure of a multihop cellular network. Each frame consists of general and backhaul downlink (DL) subframes. The frame header (FH) includes the frame preamble and control information such that each user can obtain information that is necessary for scheduling the upcoming data transmission and reception, and their destinations by receiving the control information.

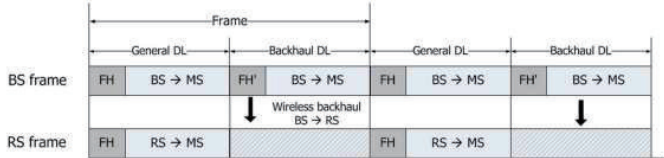


Fig. 3. Downlink frame structure of multihop cellular networks

Simulation Results

- Especially, to solve the problem of high computational complexity, we propose a sub-optimal scheme which more focuses on the allocation of beams.
- Moreover, a heuristic scheme which can be operated in distributed manner is also proposed to further reduce the computational complexity.

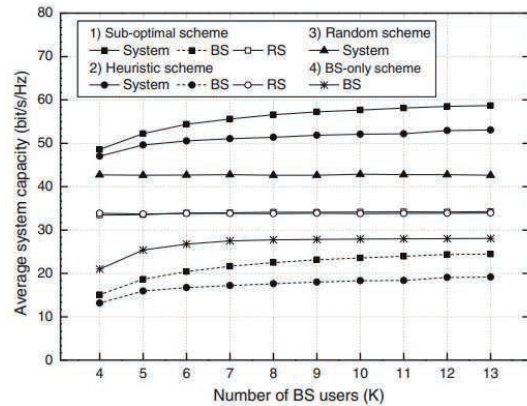


Fig. 5. Average capacity versus the number of users connected to BS K when the distance between two RSs is 500m

- In Figure 5, by comparing the capacity of the proposed scheme with that of BS-only scheme, we can find that the capacity of cellular network can be improved significantly by using RSs, which verifies the usefulness of using RSs.
- Moreover, we can find that as the number of BS users increases, the system capacity is increased by 14–38 % when the sub optimal scheme is used and by 10–25 % when the heuristic scheme is used, compared with that of the random scheme.
- This result confirms that our proposed resource allocation can improve the multihop cellular network.

Conclusions

- In this poster, resource allocation schemes for multihop cellular networks using directional transmission based on smart antenna have been explored.
- To solve the problem of high computational complexity, sub-optimal scheme has been proposed. Moreover, a heuristic scheme has been also proposed to further reduce computational complexity.
- Through simulations, we have investigated the capacity of the proposed schemes and conventional schemes and found that the performance of the multihop cellular network can be improved by using our proposed schemes.
- We have also found that although the achievable capacity decreases, the heuristic scheme is better than the sub-optimal scheme in practical systems.

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Physical causal reasoning in human and machine

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Introduction

- A longstanding debate in intuitive physics:

“Does our physical reasoning rely either on **simulations** or **rules and logic**?”

Physics by heuristic

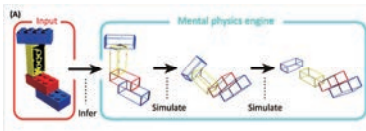
- Reasoning based on simple rules, physics parameters



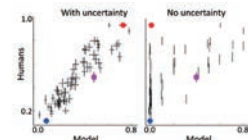
(Hegarty, 2004)

Physics by mental forward simulations

- Simulations by temporal unfolding (one time step after another)

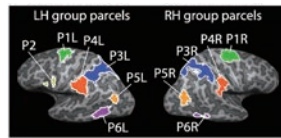


(Battaglia et al., 2013)



Computational building blocks in human brain

- Physics engine-like brain areas, *physics area* (Fischer et al., 2016; Pramod et al., 2022)



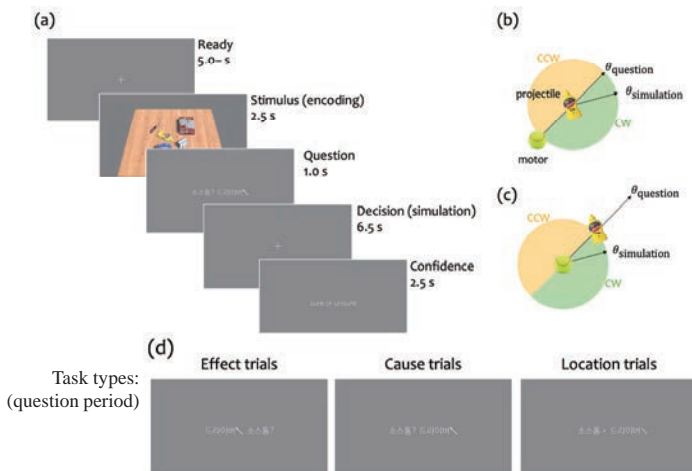
- Unknown question (see Smith & Vul, 2014):

“Does human physical reasoning solely rely on **forward simulations**?”

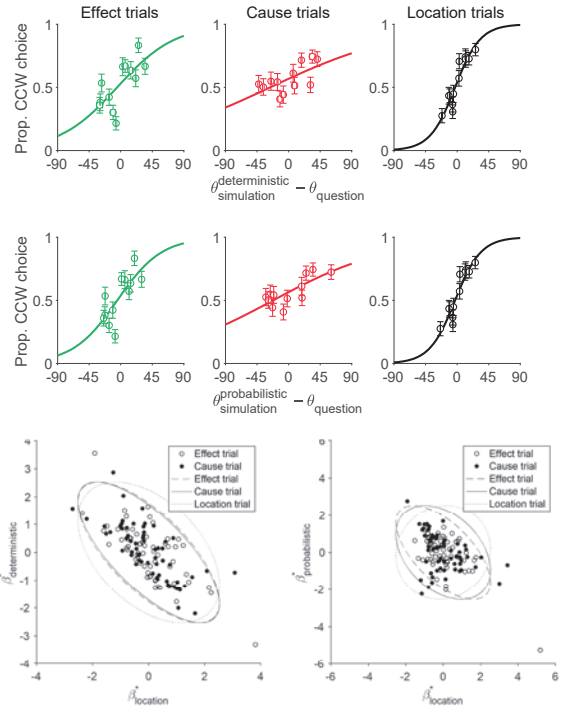
Methods and Results

- We collected human behaviors, neural (fMRI), and computer simulation (3D Unity™) data
- Compared the behaviors with model predictions

Task structure (fMRI experiment)

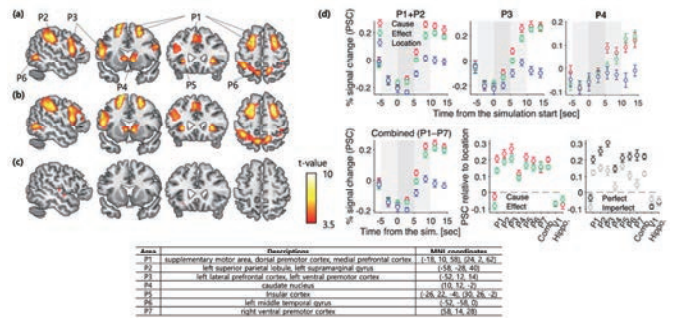


Summary of human behavioral data (N = 57)



- Decision strategies (heuristic, simulation regressors) are competing each other → strategy exclusiveness
- Decision strategy exclusiveness increase for simulation tasks
- Strategy exclusiveness reduce in cause task compared to effect task

Brain areas recruited in the simulator task compared to location task



Conclusions

- Mutually selective between forward simulation- and heuristic-based choice strategies
- Strategy selectiveness becomes weakened for when they are inferring about the cause rather than the effect
- The individual differences of strategy selectiveness are associated with the brain activities from the so called physics area reported in the recent literature



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Change of film coating solvent to replace the use of Dichloromethane in a moisture-sensitive G-tablet's coating system

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Introduction

- Film coating is the application of a thin polymer layer to the surface of a tablet for several purposes. It can strengthen the tablet, protect it from moisture, add color, mask the taste, and make it easier to swallow.
- Film coating formulation for Immediate release basically consists of solids such as polymer, plasticizer, and colorant, and solvent. As the coating solvent, volatile and quick-drying organic solvent such as alcohol or Dichloromethane(DCM) have been used typically. Among them, particularly DCM has excellent performance as a coating solvent, but presented problems in handling, operator safety, and environmental emissions etc.
- We conducted a study to replace DCM-based coating with Alcohol-based coating using moisture-sensitive tablets, G-tablet. In addition, we evaluated the effect of moisture exposure during the alcohol-based coating and confirmed the moisture barrier function of the tablets over time.

Experimental / Methods / Results

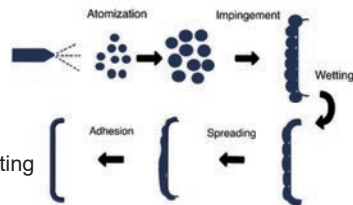


Fig.1 The process of film coating

- About the film coating process :
A fine mist of coating suspension created by a spray gun impinges against the tablet surface, wets, and dries immediately after then. The coating suspension is distributed through the dynamic motion of the tablets rubbing against one other, and it is spread, adhered to the surface. In fact, all the process take place at the same time. The key to film coating is get the surface slightly wet and immediately dry.
- We attempted to change the DCM-based coating system of the Drug product to an Alcohol-based coating system about moisture-sensitive G-tablets. And the coating was performed at the Lab-scale.
- The coating formulations of Drug products and Lab-coatings are as shown in Table 1, and the coating parameters are as shown in Table 2.

Table 1. Coating formulations of Drug product and LAB-coated G-tablet

Ingredient	Purpose	Drug product (mg/1T)	Lab-coating (mg/1T)
Hypromellose 2910	coating agent	4.0	4.0
Polyethylene Glycol 6000	coating agent	0.4	0.4
Titanium Dioxide	shading agent	0.6	0.6
Dichloromethane	organic solvent	35.0	-
Ethanol(95%)	organic solvent	21.6	50.0
Solids Content (% w/w)		8.1 %	9.1 %

Table 2. Coating parameters of Drug product and LAB-coated G-tablet

Coating parameter	Drug product	Lab-coating
Coating formulation	DCM-based	Alcohol-based
Tablet charge	5,580 g	140 g
Machine-scale	Commercial	Lab
Number of gun	3	1
Pan speed	Initial(~30min): 1-3 rpm, Main(30min~): 3-7 rpm	2 rpm
Inlet temperature	80 °C	80 °C
Exhaust temperature	40 °C	40 °C
Tablet bed temperature	38-40 °C	38-40 °C

- After coating with a weight gain of 3.8%, the tablet properties were summarized by comparing them with those of uncoated tablets and the Drug products. (See Fig.2)

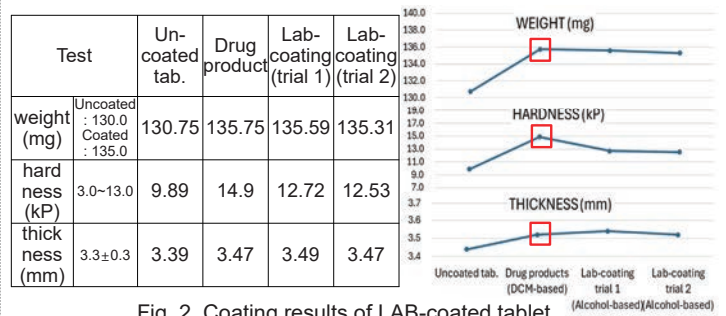


Fig. 2. Coating results of LAB-coated tablet

- A stability test was conducted according to the coating weight gain in orders to evaluate the effect of moisture exposure during coating and to confirm the moisture barrier function over time. (For 48 hours exposure at 25°C, 60% RH)
- After 48 hours of exposure, the hardness reduction rate was significantly lower than that of the uncoated tablet, confirming that the Alcohol-based coating system has a moisture barrier function. In addition, the optimal range of coating weight gain for product stability was confirmed to be 3.8% to 5.4%. (See Fig. 3)

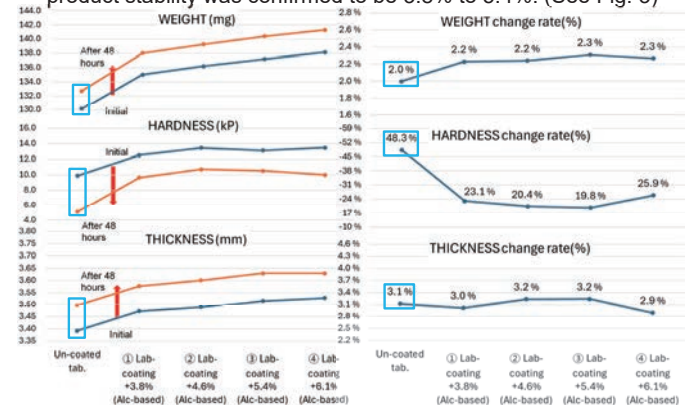


Fig.3 Changes in tablet properties of the un-coated and Lab-coated G-tablets after 48 hours of exposure at 25°C and 60% RH

Conclusions

- In this study, we conducted experiments to change the DCM-based coating system to an Alcohol-based coating system for moisture-sensitive G-tablets. Through this, we have confirmed the performance of the Alcohol-based coating system, which shows a moisture barrier function.
- Our ultimate goals is to find the optimal coating conditions that protect against moisture penetration during coating process and ensure product stability with effective moisture barrier function without using DCM solvent.
- For this, we will conduct additional research to find optimal coating conditions in respects of air conditioning system, spraying system etc.

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A review of church history as a process of realizing freedom - Home Church as a realization of the world spirit

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Introduction

- Hegel says that the principle and direction of the spirit of the times that has continued until now is 'the expansion of freedom consciousness. 'History is developing as it converges with the expansion of freedom consciousness.
- Unification Thought views human history as the history of the providence of restoration. History is said to be a history of providence that returns to God's purpose of creation. Human history can be seen as the history of recovering the freedom lost due to the fall of man.
- This paper suggests that to fully expand freedom, we must move toward a home church system.

Hypothesis/Historical Consideration/Future

1. The purpose of religion

- is to realize a world of complete freedom. Therefore, Christian history can be said to be a process of realizing freedom. The Unification Church believes that the purpose of the Providence of Restoration is to restore the complete freedom inherent in creation. The form of church that emerges as a result of the restoration of freedom will be the home church.

2. Western history as the spread of freedom:

- The history of the West, which entered human consciousness, unfolded through the processes of ancient society, feudal society, despotic society, and democratic society.

3. Christian history as the spread of freedom:

- While the Old Testament was an era in which freedom was bound by law and freedom from teaching was bound by law, the New Testament was an era in which Protestantism acquired freedom in faith. And the Completed Testament Age is an era in which complete freedom can be enjoyed when one conforms to God's will and heart. Consistent with God's will and heart

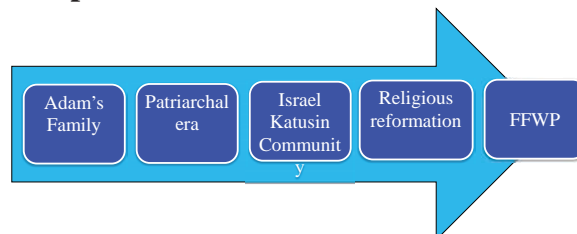
4. What does freedom mean to believers?:

- It should be 'freedom for' rather than 'escape from'. When this consciousness of freedom changes, humans can realize freedom 'for God' and 'for others'. Through this maturation of free will, humans can free themselves from evil and become consistent with God's will and heart. We can fulfill our human responsibilities for the completion of God's kingdom. The word of God and what can be called 'Yes' are true freedom, but there is no freedom to be called 'No'. By saying "No," you fall into non-existence with no relationship with God.

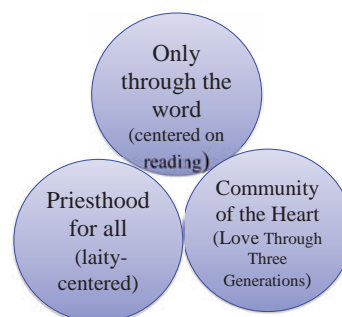
5. Home Church as an Expansion of Freedom:

- God tried to establish a home church starting in the Garden of Eden, but due to the fall in Adam's family, the home church could not be established. The home church becomes a foundation of expectation for the coming of the Messiah, the savior.

God's providence to establish a home church



Home Church Components



Conclusions

- The self-development of the absolute spirit mentioned by Hegel refers to the spread of free will. The history of Christianity led directly to the spread of free will, which resulted in today's Western Protestantism. However, today's Christianity does not realize complete free will, and the spread of free will is progressing. It is believed that the full realization of free will is achieved in the home church.
- A home church is a church that can realize the spirit of religious reform, that is, priesthood for all people, only through the word and faith. A home church is a laity-centered church where all laypeople present a model of the kingdom of God through words and faith from the perspective of a priest. As the founder of the Unification Church, Reverend Sun Myung Moon, said, the home church is the base of heaven and the destination of providence where complete freedom is enjoyed.

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