Examination of the effect of a marital symmetrical communication pattern and the amount of communication on problem-solving: Attempt to apply Integrated Information Theory to the family system

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ABSTRACT. The purpose of this study is to elucidate the qualities of family systems that are more capable of solving problems. In this study, we applied the schema of Integrated Information Theory (IIT), which explains the phenomenon of consciousness, to family research and tested the following hypothesis: higher symmetry leads to greater problem-solving ability in more communicative couples. We understood the couple's difference from the symmetry of their communication, and the couple's interaction from how much they communicate. We also distinguished between ordinary and problem contexts when investigating the difference and interaction in couples. The questionnaire survey was conducted to 312 married respondents (156 males, 156 females; average age 45.18 years). We took the couple's problem-solving ability as a dependent variable, and communication score, symmetry score, and an interaction term for both scores as independent variables, and performed hierarchical regression analysis for both ordinary and problem contexts respectively. As a result of this analysis, it was shown that, in ordinary contexts: (1) greater symmetry means greater solution-oriented attitude in more communicative couples; and (2) relationship-maintaining attitude is greater in more communicative and complementary couples. It was also shown that, in problem contexts: (1) solution-oriented attitude is greater in more communicative couples; and (2) complementary means greater relationship-maintaining attitude in more communicative couples. In the future, it will be necessary to test the hypothesis having controlled for the nature of the problem.

KEY WORDS: Integrated information theory, Family system, communication, problem-solving

Introduction

Integrated Information Theory (IIT) is a theory in neuroscience that explains the multidimensional phenomenon of consciousness. IIT was presented by Tononi (2004) as neuroscientists have sought to explain the phenomenon of consciousness in recent years. There are around 100 billion neurons in the entire brain, around 80 billion of which are found in the cerebellum. The thalamocortical system, which is made up by the cerebral cortex and the thalamus, contains around 20
billion neurons. If the cerebellum is removed due to some disease, language and movement become difficult. No problems arise, however, with consciousness. This means that the multidimensional phenomenon of consciousness cannot be explained according to the number of neurons. Integrated Information Theory is one theory for solving this sort of problem. This theory posits that the phenomenon of consciousness arises from the difference (diversity) and interaction (integration) amongst neurons. Difference and interaction create consciousness. Difference and interaction mean greater amounts of information.

Attempts are underway to apply IIT as a system theory to spousal and familial systems. When applying IIT to family research, three points need to be discussed: (1) what constitutes the difference in a family; (2) what constitutes interaction in a family; and (3) what is the product created by difference and interaction in a family. However, no clear answers to these questions have been obtained. Here, Wakashima et al. (2018) investigated the hypothesis that "the couple who has the higher score in both difference and interaction has higher problem-solving abilities and resilience than other couples". This study measures difference in couples through three facets: "ways of thinking", "preferences", and "abilities". Interaction in couples is perceived from amounts of communication that are measured in two ways: from verbal communication such as a couple's conversations, and non-verbal communication such as eating dinner together and sharing their time. The study posits two products of difference and interaction in couples and families: the couple's problem-solving ability and family resilience. "Family structures" (e.g., "bonds within the family", "power relations", "openness"), and "family functions" (e.g., "family's problem-solving abilities", "family resilience"), have often been used as variables in research into families. The phenomenon we experience as consciousness is considered not as a single amalgamation constructed from difference and integration, but rather as a function they create as a whole. Accordingly, Wakashima et al. (2018) used variables related to the couple's “family functions”, such as problem-solving ability and family resilience, as outcomes. Wakashima et al. (2018) examined the influence exerted on a couple's problem-solving ability and family resilience by the difference and amount of communication within the couple. The results indicated that the following two points were positively related to problem-solving ability and family resilience: (1) less difference in “ways of thinking” and “preferences”; and (2) higher amounts of communication within the couple. In other words, the hypothesis was not supported. This may be due to the following reasons.

(1) First, there is the possibility that the three facets used to measure the difference in couples, i.e., “ways of thinking”, “preferences”, and “abilities”, ended up measuring how bad a couple’s relationship is. Namely, there may have been a negative bias. Therefore, it is
necessary to measure the difference in couples in a manner that avoids the occurrence of negative bias as much as possible. One way of doing this is, as in the present study, to examine differences that arise within couples by measuring symmetry and complementarity. To start, “difference” in integrated information theory refers to the difference that can produce the amount of information. Symmetry is defined as being based on homogeneity, whilst complementarity is based on heterogeneity (Watzlawick et al., 1967). Considered from the perspective of information amounts, meanwhile: if complementarity is where A makes a suggestion, and B accepts that suggestion, and the amount of information held by A is 1, then the amount held by AB will also be 1. On the other hand, if symmetry is where A makes a suggestion, B also makes a suggestion, the information amount held by A is one, and the information amount held by B is also 1, then the amount held by AB will be 2. Here, the value of 2 is the minimum; there is also the possibility that the two suggestions may also lead to a third perspective. Thus, in this study, we operationally defined symmetry as high information content and complementarity as low information content.

(2) Second, amounts of information may differ between ordinary circumstances and extraordinary circumstances. In ordinary circumstances, there may not be a need for so much information. Ordinary circumstances are situations in which there are no problems or problems are well managed when they occur. In such situations, it is thought that problem solving is achieved by selecting and executing the solutions usually used by convergent thinking. On the other hand, extraordinary circumstances are considered to be situations in which a novel problem arises or emerges because of inadequate handling of the problem. In such situations, it is thought that the problem can be solved by creating a new solution through diffusional thinking and then selecting and executing an action through convergent thinking. Thus, the amount of information required is different between ordinary and extraordinary circumstances because the thinking process in problem-solving is different between them. Accordingly, a variable for ordinary/extraordinary circumstances needs to be introduced.

Adding to the reasons and solutions above, we have also chosen to measure family functions by taking problem-solving ability, a function easily interpretable within a narrow range, as our dependent variable. Previously, problem-solving ability and resilience have been used as dependent variables, but since resilience indicates a potential ability of the family, it may not be appropriate to handle it as a result. In other words, it is difficult to interpret. The purpose of this study is therefore limited to an examination of problem-solving ability, and we conducted our investigation having posited the following hypothesis:

Higher symmetry leads to greater problem-solving ability in more communicative couples.

Methods
**Procedure**

We used a survey company to conduct an online questionnaire survey of 312 married couples of Japan (156 males, 156 females; average age 45.18 years, ±11.708). We included details explaining the survey (regarding the aims of the survey, handling of personal information, feedback on the results, and consent) at the start of the questionnaire, and obtained responses only from participants who gave their consent.

**Scales**

The questionnaire was composed of three parts. Part A asked respondents to recall and respond to questions about “ordinary circumstances”. Part B asked respondents to recall and respond to questions about “circumstances in which the couple or family is facing an issue or problem”. Part C asked respondents to recall and to respond to questions about “the couple and/or the family.” For counterbalancing, half of the sample were given questionnaires structured in the order “Part A → Part B → Part C” and the other half “Part C → Part B → Part A.” At the start of Part B, respondents were asked to freely describe the problematic circumstances they pictured. The following scales were used.

**1) Face sheet**

We used the survey company’s respondent attribute data for age and sex. We included three other questions at the start of the questionnaire about a number of children, spouse cohabitation/non-cohabitation, and child cohabitation/non-cohabitation.

**2) Scale for measuring the difference in couples**

We asked for responses to a 22-item 5-point scale questionnaire formed by adding one item, “22. Difference in roles,” to the 21-item 5-point scale created by Wakashima et al. (2018) for measuring the difference in couples. This scale consists of three factors: “ways of thinking”, “preferences”, and “abilities”. We asked for responses here in Part A and Part B respectively. We used it because we thought that the differences between couples could be measured in three specific aspects. However, a negative bias between the couple could have arisen. Note that since the aim of this study is to investigate the difference that produces information in a couple from symmetry in the couple’s communication, we have not used this as a variable in testing our hypothesis.

**3) Scale on Symmetry and Complementary in Conversation (SSCC)**

We asked for responses to the 13-item 6-point scale created by Kobayashi (2012) for measuring symmetry in conversation. This scale is a single-factor structure. Higher total scores on this scale indicate conversational symmetry, whilst lower total scores indicate conversational complementarity. The instructional text was altered before use to ask the respondent to imagine the conversation with their spouse. "You will argue with your spouse until you are satisfied, even if you disagree with your spouse," are examples of items such as. We asked for responses here in Part A and Part B respectively.

**4) Communication scale**

We asked for responses to the 14-item...
7-point communication scale created by Wakashima et al. (2018). This scale uses twelve items of direct communication scale (Itakura, 2013), and two items assessing “how good/bad the relationship between the father and mother is” (namely: father and mother spend a lot of time talking with each other; father and mother often eat dinner together), which is a subscale of “interparental concordance scale for inquiring into mother-father relationships”(Hida & Kariya, 1992). This scale is a single-factor structure. Higher total scores on this scale indicate higher amounts of communication in couples. "1. talking about everyday relationships" is an example of an item. We asked for responses here in Part A and Part B respectively.

(5) Family Problem Solving Scale (FPSS)

We asked for responses to the 25-item 4-point family problem-solving scale created by Saito et al. (2020). A couple’s problem-solving ability is defined as “the skills possessed by a couple to make constructive progress through communication in the processes of periodically defining issues, clarifying the details, conceiving of solutions, making decisions, and implementing and testing solutions” (Saito et al. 2020). The scale is composed of two factors: “attitude to solve the problem” and “attitude to maintain the relationship”. "Attitude to solve the problem" refers to the propensity of couples to produce and execute solutions, communicate honestly with each other, and engage in collaborative problem-solving. "Attitude to maintain the relationship" refers to the tendency for couples to talk peacefully and try to prevent the deterioration of the relationship by not arguing. Higher total scores for these base scales indicate greater problem-solving ability in a couple. We asked for responses here in Part C.

(6) Family resilience scale

We asked for responses to the 30-item 4-point family resilience scale created by Ohyama and Nozue (2013). Family resilience is defined as how a family recovers and remoulds as a family unit through critical circumstances (Walsh, 1998). This scale is composed of five factors: “connection”, “trust in family ability”, “balance between relationships and the individual”, “spirituality”, and “socioeconomic resources”. Higher total scores for these base scales indicate greater family resilience. We asked for responses here in Part C. Family resilience is a concept that broadly predicts how a family adapts, structured not only by the family’s problem-solving skills but also by notions such as how well the family is supported by the society around it, their ability to reframe unsolved problems in a positive light, and their ability to accept some problems as unsolvable. We used this scale to measure the holistic adjustment of the family. However, this study supposes that difference and interaction in a couple create amounts of information that are considered to increase the number of problem-solving strategies available to the couple; accordingly, when testing our hypothesis, we chose to use only the FPSS, which directly measures problem-solving skills.

(7) The item for measuring social desirability bias
We asked for responses to the notion that “generally, the couple needs to share the same opinions” in a 1-item, 4-point fashion, in order to measure social desirability bias in couples. We excluded from our analysis any participants who gave the response “4. Very applicable” to this question item. We asked for answers here after participants had finished responding to Part C.

(8) Manipulation checks

We asked for responses on a 3-item 4-point basis regarding the degree to which participants were able to picture “ordinary circumstances” in Part A, “circumstances in which the couple or family is facing an issue or problem” in Part B, and “the couple and/or the family” in Part C. We excluded from our analysis any participants who responded “1. Not at all” to one or more of the question items. We asked for responses here after participants had finished responding to the question item for measuring social desirability.

Ethical considerations

The survey was conducted anonymously. We paid consideration to informed consent and invasiveness, indicating at the beginning of the questionnaire that: the particulars of the survey and response thereto are voluntary; participants may refuse or stop providing responses; participants will suffer no loss even if they refuse or stop providing responses; responses will be processed statistically and not be personally identifiable; and the results of the survey will be used solely for the purposes of research.

Results

We excluded from our analysis any participants that responded “4. Very applicable” to the question item for measuring social desirability (“generally, the couple needs to share the same opinions”), and any participants that responded “1. Not at all” to one or more of the question items in our manipulation checks regarding the circumstances that the questionnaire asked the participants to imagine. We thus excluded 31 participants from our analysis, leaving 281 analysis subjects. Table 1 shows the statistical values recorded for each scale.

Sorting the nature of the problems

On the basis of the free responses obtained for the “circumstances in which the couple or family is facing an issue or problem” as pictured in Part B, we sorted the nature of the problems described into six categories: “problems for the couple”, “problems for the family”, “problems for the individual”, “external problems”, “uncategorizable”, and

| Scale                          | n  | min | max | M   | SD  |
|-------------------------------|----|-----|-----|-----|-----|
| Ordinary: Symmetry            | 281| 1.77| 5.23| 3.50| 0.52|
| Problem: Symmetry             | 281| 2.08| 5.62| 3.51| 0.52|
| Ordinary: Communication       | 281| 1.43| 7.00| 4.97| 1.04|
| Problem: Communication        | 281| 1.21| 7.00| 4.95| 1.07|
| Solution-oriented attitude    | 281| 1.06| 4.94| 3.29| 0.68|
| Relationship-maintaining attitude | |    |     |     |     |
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“The problems for the couples” group was categorized as those that are described as occurring between two parties with a spouse. The most common statements were about differences of opinion and sense of values with spouses and about marital conflicts. The “problems for the family” group categorized problems that are described as occurring between children and their parents’ generation and relatives, as well as problems that affect the whole family, such as the economic situation and caregiving issues within the family. The most common statements were about child care, the economic situation in the home, and parental care issues. “Problems for the individuals” group was categorized as those that were described as being problems that the respondents themselves were having. The most common statements were about the respondents’ own work troubles, mental instability, and health problems. “External problem” groups were categorized as those describing conflicts with persons outside the family or regarding social problems. The most common statements were descriptions of disasters. “Uncategorizable” group was categorized as those that are impossible to classify without a specific description of the problem.

Some responses were difficult to judge between being problems for the family or for the couple, such as financial issues or matters relating to old age; we sorted such responses as “problems for the family”. Table 2 is a frequency distribution chart for each category. “Problems for the family” represents the majority of responses, at n=146, followed by “problems for the couple” at n=56, which covers 19.9%. In total, 71.9% of respondents pictured issues that arise within the household, i.e., “problems for the couple” or “problems for the family,” whilst only 1.4% of respondents pictured “external problems” such as natural disasters.

**Examining the relationships between variables**

We performed hierarchical regression analysis for ordinary and problem contexts respectively, using: solution-oriented attitude score and relationship-maintenance attitude score as dependent variables; and communication score, symmetry score, and an interaction term for both scores as independent variables. In order to reduce the risk of multicollinearity when adding the interaction term, we standardized the independent variable scores to have an average of 0 and a standard deviation of 1. Our method of analysis is as follows. In the first step, we added the communication score and symmetry score. In the second step, we added the interaction term for both scores, and tested the significance of

| Category          | Couple | Family | Individual | External | Uncategorizable | N/A | Total |
|-------------------|--------|--------|------------|----------|-----------------|-----|-------|
| n                 | 56     | 146    | 10         | 4        | 2               | 63  | 281   |
| %                 | 19.9%  | 52.0%  | 3.6%       | 1.4%     | 0.7%            | 22.4%| 100%  |
any increase in the coefficient of determination. Here, a significant increase in the coefficient of determination indicates that the influence of symmetry score on solution-oriented attitude score and relationship-maintenance attitude score varies according to communication score level. In order to check the significance of the interaction term, we obtained simple linear regression lines for communication scores with standard deviations of +1 and -1 respectively.

Table 3 shows the results of hierarchical regression analysis performed using ordinary-context communication and symmetry.

First, when we took solution-oriented attitude score as a dependent variable, and added ordinary-context communication score and symmetry score, communication score ($\beta=.59$, $p<.001$) showed a significant relationship. When we then added the interaction term for ordinary-context communication score and symmetry score, the variation of the coefficient of determination increased significantly ($F(1,277)=4.86$, $p<.05$), and the interaction term ($\beta=.11$, $p<.05$) showed a significant relationship for the two scores.

Next, when we took relationship-maintenance attitude score as a dependent variable, and added ordinary-context communication score and symmetry score, significant relationships were shown for communication score ($\beta=.11$, $p<.05$) and symmetry score ($\beta=.38$, $p<.001$). Next, the variation of the coefficient of determination was not significant ($F(1,277)=1.16$, $p>.10$) when the interaction term for ordinary-context communication score

| Table 3: Hierarchical regression analysis for ordinary-context communication and symmetry |
|-----------------------------------------------|
| **Step 1** |
| Communication | .59 *** |
| Symmetry | .02 |
| **Step 2** |
| Communication x symmetry | .11 * |
| Adjust $R^2$ | .35 *** |
| $\Delta R^2$ | .01 |

| Table 4: Hierarchical regression analysis for problem-context communication and symmetry |
|-----------------------------------------------|
| **Step 1** |
| Communication | .61 *** |
| Symmetry | .03 |
| **Step 2** |
| Communication x symmetry | -.05 |
| Adjust $R^2$ | .38 *** |
| $\Delta R^2$ | .00 |
and symmetry score was added.

Table 4 shows the results of hierarchical regression analysis performed using problem-context communication and symmetry. First, when we took solution-oriented attitude score as a dependent variable and added problem-context communication score and symmetry score, a significant relationship was shown for the communication score ($\beta=.61$, $p<.001$). Next, when we added interaction term for problem-context communication score and symmetry score, the variance of the coefficient of determination was not significant ($F(1,277)=1.22$, $p>.10$). Next, when we took relationship-maintenance attitude score as a dependent variable and added ordinary-context communication score and symmetry score, significant relations were shown for communication score ($\beta=.14$, $p<.05$) and symmetry score ($\beta=.41$, $p<.001$). Next, when we took relationship-maintenance attitude score as a dependent variable and added the interaction term for problem-context communication score and symmetry score, the variance of the coefficient of determination increased significantly ($F(1,277)=16.55$, $p<.001$), and a significant relationship was shown for the interaction term ($\beta=-.22$, $p<.001$).

Lastly, in order to check the interaction term, we obtained simple linear regression lines from a regression equation using communication scores with standard deviations of +1 and -1 respectively. These results suggest that, in couples which in ordinary contexts have more communication, greater symmetry will mean a greater solution-oriented attitude (Figure 1). Furthermore, in couples with less symmetry in problem contexts, more communication will mean greater relationship-maintaining attitude (Figure 2).

![Graph showing interaction effect between ordinary-context communication and symmetry](image-url)
**Discussion**

This study applied the Integrated Information Theory (IIT) schema to family systems, controlled between ordinary and problem contexts, and examined the effect exerted by communication amount and symmetry between couples on problem-solving ability. Below, our hypothesis will be considered from the perspectives of solution-oriented attitude and relationship-maintaining attitude.

**Examining factors related to solution-oriented attitude**

Our examination of solution-oriented attitude indicated that greater symmetry means a greater solution-oriented attitude for more communicative couples in ordinary contexts. Accordingly, couples with greater symmetry and more ordinary-context communication may have a better capacity for solution-devising and decision-making. These results support the hypothesis that greater symmetry will indicate greater problem-solving ability in more communicative couples in ordinary contexts. In Integrated Information Theory, as described by Tononi (2004), the phenomenon of consciousness (information amount) is created by *interaction* (integration) and *difference* (diversity) amongst neurons. In this research, we applied this IIT schema to a study of the family, and examined (1) symmetry as the *difference* in the family, (2) amount of communication as the *interaction* in the family, and (3) problem-solving ability as the product created by *difference* and *interaction*. Wakashima et al (2018) measured difference

![Figure 2: Interaction effect between problem-context communication and symmetry](image-url)
from three facets, namely “ways of thinking,” “preferences,” and “abilities,” but this approach was problematic due to the possible influence of negative bias on the responses from the couples. In this study, we measured the **difference** in the couple through communication symmetry and complementarity, so as to avoid the influence of negative bias insofar as possible. Complementary communication indicates consensus in the opinions of a couple; one spouse makes a suggestion, and the other spouse accepts that suggestion. Meanwhile, symmetrical communication indicates that the spouses present differing opinions and a new perspective may arise from their differing views. The results of our study prove that, in ordinary contexts, couples that communicate more, and more symmetrically, will have the greatest amounts of information, thus having a positive influence in the division of solutions and in decision-making.

Meanwhile, in problem contexts, only the communication amount positively influenced solution-oriented attitude, and symmetry had no relation. Conceivably, this is related to the nature of the problems pictured by respondents in our study. “Problems for the couple” between spouses, and “problems for the family” such as childcare and family finances, and familial connections in old age, represented 71.9% of all responses in this study. These familial and spousal problems are issues that arise within the family system. Meanwhile, “external problems” such as natural disasters and accidents can be understood as issues that arise outside of the family system. While reaching a consensus amongst the family’s views and strengthening bonds can itself be an effective means for solving issues that arise within the family system, for problems that arise outside of the family system it may be more effective to have family members conceive of a large number of possible solutions. In other words, less information is required to solve family-internal problems than family-external problems. Since the majority of the problems recalled in our study were family-internal, in problem contexts communication amount was the only factor to positively influence solution-oriented attitude. In future research it will be necessary to test our hypothesis having controlled for the nature of the problem (i.e., whether it arises within or outside of the family system).

**Examining factors related to relationship-maintaining attitude**

Our examination of relationship-maintaining attitude indicated that more communication means greater relationship-maintaining attitude for complementary couples in problem contexts. Accordingly, couples with less symmetry and more problem-context communication may have less conflict in problem-solving. Symmetry involves repeating assertions that conflict with the other partner, and thus whilst this increases the amount of information within the couple, there is also the possibility of a negative influence being exerted on the relationship between the two spouses. In fact, regardless of context, symmetry showed a negative influence on relationship-maintaining attitude. In complementary couples, there will
be more communication in which one spouse accepts the other’s assertions, which stabilizes the couple’s relationship from the perspective of relationship-maintaining attitude. As discussed above, if the nature of the problem facing a family is internal to the family system, then stabilizing the couple’s relationship itself can be an effective means of solution.

However, if complementary roles become fixed, the ideas of only one spouse are always used, therefore leading to lower amounts of information. Greater amounts of information may be required for problems external to the family system; when facing such problems, maintaining the couple’s relationship may not constitute an effective means of solving the issue. Thus, whilst we can say that it is important to have less symmetry and more communication, when the aim is led by a relationship-maintaining attitude, i.e., stabilizing the couple’s relationship, there is nonetheless a need for the detailed investigation into the role played by relationship-maintaining attitude in a couple’s problem-solving ability after having controlled for the nature of the problem.

Conclusion

The purpose of this study was to apply Integrated Information Theory to the family system. We thus investigated the influence exerted on the problem-solving ability by how much and how symmetrically a couple communicates. Our results show that the study’s hypothesis is supported only in ordinary contexts in which solution-oriented attitude is taken as a dependent variable. Meanwhile, the hypothesis found no support in ordinary contexts in which relationship-maintaining attitude is taken as a dependent variable, nor in problem contexts.

One issue with our study is the bias in the nature of the problems recalled by our respondents. We did not control for the nature of the problems recalled by our respondents for problematic contexts. As a result, in 71.9% of cases, respondents recalled problems that arose within the family system. If the setting of a problem is outside of the family system, more information is required to solve the issue than in family-internal settings. This means that whilst increased communication and relationship maintenance may themselves be effective means for solving problems within the family system, family-external problems require not only more communication but also the creation of symmetrical communication patterns and the conception of numerous possible solutions. In future research, it will be necessary to test the hypothesis after having controlled for the nature of the problem. Additionally, although more symmetrical and communicative couples may have better problem-solving ability, if they become too symmetrical then relationship maintenance becomes difficult, which thereby lessens problem-solving ability. Looking to the future, further investigation may be needed into the connection between a couple’s solution-oriented attitude and relationship-maintaining attitude.
Acknowledgements

This study received the following grant. We appreciate this grant. JSPS KAKENHI Grant Number JP 17K04191

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