Measurement of Creativity: The tripartite approach for creative thinking

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Abstract

The purpose of this paper is to propose a new measurement method of creativity. Based on the tripartite thinking model (TTM), this paper developed the tripartite creativity test (TCT). The TCT was generated by considering creative process in problem solving. The TCT defines creativity as the interaction of three modes of thinking: logical thinking, critical thinking, and lateral thinking. This model is apart from traditional definition of creativity that prescribes it as the skill for producing new and useful things. The TCT consists of three subtests in accordance with the tripartite model: logical thinking test, critical thinking test, and lateral thinking test. The psychometric characteristics were examined for this new measure. The reliability was examined by inter-rater agreements. The construct validity was examined by confirmatory factor analysis (CFA) and the criterion-related validity was examined by covariance structure analysis. The result showed that the TCT had sufficiently high reliability and fit the data reasonably well.
Measurement of Creativity: The tripartite approach for creative thinking

Measuring creativity is one of the toughest challenges in creativity research. The literature observed that though there are many sorts of creativity measurements, no single measure has been accepted widely.

Plucker and Makel (2010) summarized creativity measurements as shown in Table 1. According to those authors, measures are classified into four categories with referent to Rhodes’ (1961) framework of process, person, product, and press. All measurements listed in the table have essential problems concerning the definition and operationalization of creativity. Consequently, it is almost impossible to evaluate precisely to what degree an individual is creative by employing the preexisted tests and scales.

Table 1. Creativity measurements
Representative measurements are selected and arranged from Plucker and Makel (2010, pp. 51-60)

<table>
<thead>
<tr>
<th>Author</th>
<th>Measurement</th>
<th>Category</th>
<th>How to measure</th>
<th>Standard to measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torrance (2008a, 2008b)*1</td>
<td>TTCT</td>
<td>Process</td>
<td>Divergent thinking test</td>
<td>Scoring manuals</td>
</tr>
<tr>
<td>Goff and Torrance (2002)</td>
<td>ATTA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carson, Peterson and Higgins (2005)</td>
<td>CAQ</td>
<td>Person</td>
<td>Questionnaire</td>
<td>Participants' self ratings</td>
</tr>
<tr>
<td>Runco, Plucker and Lim (2001)</td>
<td>RIBS</td>
<td>Person</td>
<td>Questionnaire</td>
<td>Participants' self ratings</td>
</tr>
<tr>
<td>Amabile (1982)</td>
<td>CAT</td>
<td>Product</td>
<td>Experts' judgement</td>
<td>Judges' subjective standards</td>
</tr>
<tr>
<td>Amabile, Conti, Coon, Lazenby and Herron (1996)</td>
<td>KEYS</td>
<td>Press</td>
<td>Questionnaire</td>
<td>Participants' self ratings</td>
</tr>
</tbody>
</table>

*1 The first version of TTCT was developed at 1966 (Kim, 2006, p. 3)

Two measures are observed in the process category: the Torrance tests of creative thinking (TTCT) and the abbreviated Torrance test for adults (ATTA). Though the TTCT is used most widely for gauging creativity in the domain of divergent thinking (Amabile, 1996; Plucker
and Makel, 2010), there is a criticism that divergent thinking is only a part of creativity. For example, Runco (1993) pointed that divergent thinking is not synonymous with creativity and even not a criterion of creativity (p. 16). Plucker and Makel (2010) said that divergent thinking is only one aspect creative process (p. 55). To refute to these criticisms, the TTCT (Torrance, Ball and Safter, 2008) added thirteen subscales (e.g., emotional expressiveness, storytelling articulateness, and humor) to four core subscales representing divergent thinking (i.e., fluency, flexibility, originality, and elaboration). However, such attempt produced only a limited success. The TTCT provided only inadequate reliability and no validity in its manuals (Torrance, 2008a, 2008b; Goff and Torrance, 2002). For example, Torrance (2008b) reported reliability with the size of $?$ based on KR21, yet showing no description of data collection procedures, sample size, and attributes of participants. Insufficient psychometric properties hamper the TTCT to be regarded as the scientifically sound test for creativity.

In the person category, self-reporting questionnaires are used frequently to describe characteristics of creative people. In the creativity achievement questionnaire (CAQ: Carson, Peterson and Higgins, 2005), participants are asked to place checkmarks to the talents and abilities that they possess higher than average people. Similarly, Runco ideational behavior scale (RIBS: Runco, Plucker, and Lim, 2001) asks participants to answer 23 questions related to the idea creation processes; "I have many wild ideas." and "I think about ideas more often than most people." Because participants simply rate their levels of creative behavior and characteristics on their own subjective standards, it is unclear how participants define creativity. Those questionnaires can only identify characteristics of creative people.

Amabile’s (1982) consensual assessment technique (CAT) is the most popular measurement in the product category (Plucker and Makel, 2010; Kaufman and Baer, 2012; Reiter-Palmon, Robinson-Morral, Kaufman, and Santo, 2012). It aims to rate creative products
which are visible to observers. In this technique, those who made creative products are considered as creative. Subject experts are asked to judge the level of product quality against the standard of creativity (Amabile, 1982). However, judges do not express their internal process of evaluation and reason why they rate high and low to specific products (Kaufman and Baer, 2012). The CAT elaborately avoids how to define creativity (Amabile, 1982).

The assessing the climate for creativity (KEYS: Amabile, Conti, Coon, Lazenby and Herron, 1996; Amabile and Center for Creative Leadership, 2010) in the press category is a questionnaire that evaluates work environment and their influence on individual creativity (Tseng and Liu, 2011). The KEYS has 78 questions, e.g., "I have the freedom to decide how I am going to carry out my projects." and "I feel that I am working on important projects." These questions are answered on participants’ perceptions of business environment that may influence on the creativity.

Any measure needs to be developed with the definition of construct. If the underlying components of creativity are unclear, it is difficult to measure the whole notion of creativity. Because previous attempts haven’t dealt with the definitional problem properly, all previous measures did not meet the good level of psychometric quality.

The tripartite thinking model

Problem of previous definition

The previous definition of creativity does not make creativity clear. Amabile (1996) stated that no universal definition of creativity does exist. However, there is the widely agreed definition of creativity as known: creativity is the skill for producing new and useful things or responses (e.g., Sternberg and Lubart, 1999; Kaufman and Sternberg, 2007; Amabile, Barsade, Mueller and Staw, 2005).
The problem seems to lie in the fact that it is not clear "What is new and useful". Mayer (1999) summarized 21 papers in the handbook of creativity (Sternberg, 1999) and concluded that there is no consensus about which creativity belongs to products, processes, or people, whether creativity is personal or social, everyone have creativity or only specific people have creativity, whether creativity is general skill or specific skill, whether creativity is quantitative or qualitative (pp. 449-451). Likewise, Sternberg and Kaufman (2010) summarized 23 papers in Kaufman and Sternberg (2010) and suggested that "new" and "useful" are relative, therefore, the evaluation of creativity depends on the times and the status (pp. 467-469). From what has been said above, it seems reasonable to conclude that it is impossible to define universally and operationalize creativity according to previous definition: "new" and "useful". Therefore, this paper has to discuss essential issue again: "What is creativity?" apart from previous definition.

The tripartite thinking model

The purpose of this paper is to propose a new way to measure creativity. In order to reach this goal, this paper provides "the tripartite thinking model (TTM)" for measuring creativity. As shown diagrammatically in Figure 1, creativity is defined as “the interaction of three ways of thinking; logical thinking, critical thinking, and lateral thinking."
Many researchers described that creativity has deep relation with the problem solving, therefore, this paper holds the same attitude that creativity functions best in the creative problem solving. For example, Mayer (1992) said the creative thinking is cognitive activity to produce new solutions for problem solving (p.363). Finke, Ward, and Smith (1992) stated that problem solving is center on cognitive approach for creativity (pp. 177). The componential framework (Amabile, 1996) describes creativity as a process for attempting to reach solutions. Runco (2004) said that creativity is most obvious function of problem solving (p.658).

According to the previous studies about creative problem solving (e.g., Mumford, Mobley, Reiter-Palmon, Uhlman, and Doares, 1991, p. 106; Bransford and Stein, 1993, pp. 20-37; Procter, 2010, p. 75), it can be concluded that the creative problem solving has three core steps; the defining problem, the producing solutions, and the theorization of solutions. In the defining problem step, the current situation and the desirable situation are recognized. The
outcomes of this step are models (e.g., chart, image, and mathematical formula). The model of the current situation can be called as "as-is model" and the model of the desirable situation can be called as "to-be model". The gap lies between as-is model and to-be model is the problem. In other words, the defining problem step is the recognizing and modeling step of problem situations. In the producing solutions step, many ideas to move from "as-is" into "to-be" will be found or generated and one or some proper ideas are selected. In the theorization of solutions step, the selected ideas are arranged as a solution plan which can be performed. The solution plan has to be rational and persuadable to get cooperation from other people such as the customer, the boss, and the associates.

Considering these three steps more precisely in the viewpoint of a human cognitive and thinking process, it is found out that there are three core common activities. The first is organizing logically. In the defining problem step, the elements which compose the problem are selected, relation among them is found out, and the as-is model and to-be model are described logically. In the producing solutions step, the most rational solution plan is selected among the several alternative. In the theorization of solutions step, the reason for selecting the alternative and the implementation plan are logically organized. The second is evaluating critically. The output of each core steps are evaluated, for example, whether the models describe the problem situation correctly, whether the selected alternative is the best solution, and whether the implementation plan is practical. The third is the change of viewpoints and ideas. In each steps, when it is impossible to advance ahead according to common viewpoints and ideas, the change of them is required. In other words, three ways of thinking (i.e., logical thinking for the logical organization, critical thinking for evaluating, and lateral thinking for change) are required in every step. That is, the tripartite thinking model is the nature of creativity. The details of three ways of thinking as core components of creativity are described below.
Logical thinking

Researchers haven’t distinguished logical thinking and critical thinking clearly (this subject is to be explained later). As a result, few previous studies have focused on logical thinking theoretically and empirically. The definition of logical thinking here is "the thinking skill for selecting elements which compose the problems, finding relationships among them, and remaking models of situation" (Figure 2).

![Logical thinking](image)

Input includes five elements, i.e. "a", "3", "4", "7", "X", and relations among them are unknown. By using logical thinking, the relationship among "3", "4" and "7" is found and "3+4=7" is conducted as a result. Output of logical thinking is new or remade model consists of selected elements. Other two elements, "a" and "X", are judged unrelated to the problem.

Critical thinking

The characteristic of previous studies of critical thinking is that critical thinking is regarded as many sorts of skills including not only evaluation, but also thinking logically, attitude, knowledge, and so on. For example, Glaser (1941, pp. 5-6) said that critical thinking includes three things; an attitude of considering in a thoughtful way, knowledge of the methods of logical inquiry and reasoning, skill for applying those methods. However, attitude, knowledge and applying skill are not "thinking". Therefore, it is rational to think that Glaser's (1941) definition
of critical thinking is the thinking skill of being able to use these three things. Ennis (1962, pp. 83-84) suggested the definition of critical thinking: correct assessment of statements, in addition, indicated three dimensions of critical thinking: a logical dimension, a critical dimension, and a pragmatic dimension. The logical dimension covers understanding meanings of statements, using proper logical operators, and basic knowledge of the field in which the statements are made. The critical dimension covers judging statements. The pragmatic dimension covers judging that whether statements are exactly match the purpose of which the statements are made (pp. 84-85).

Ennis (1987) changed definition of critical thinking: reasonable reflective thinking focusing on decision what to believe or do (p. 10). There are 14 dispositions (e.g., seek a clear statement of the thesis or question, seek reasons, and try to be well informed) and 12 abilities (e.g., focusing on a question, analyzing arguments, and asking and answering questions of clarification and/or challenge) as subscales of Ennis' (1987) critical thinking. Ennis (1962) focused on only "assessment", however, Ennis (1987) extended critical thinking to wide concept containing dispositions, reasoning, decision making, and so on. Zechmeister and Johnson (1991) defined critical thinking as logical and non-bias thinking based on proper standards and evidences and noted that critical thinking has three elements: the attitude to observe attentively to the problem and to try to think of it carefully, the knowledge about the methods of logical exploration and reasoning, and the skill which can apply those methods. It seems that the previous definitions of critical thinking have too extensive conception over "thinking".

The definition of critical thinking here is "the thinking skill for evaluating the claims critically based on proper standards." The "standards" are mainly domain specific knowledge. For instance, when critical thinking evaluates Socrates's syllogism, the rules of deductive inference are used as the standards. When critical thinking evaluates the source codes of the computer programs, the knowledge of the programming language and the algorithm are used as the
standards.

The output of critical thinking is the result of evaluation. When using wrong standard or not having domain specific knowledge, it is impossible to evaluate claims correctly. The examples of critical thinking here are shown in Figure 3.

![Figure 3: Critical thinking](image)

The input of top is "3+4=7". By using arithmetic rules, critical thinking evaluated it correct. The input of middle is "2+3=6". By using arithmetic rules, critical thinking evaluated it incorrect. The input of bottom is "a ÷ X=9". By using arithmetic rules, critical thinking could not evaluate it and not found other standards, the last judgment was "??": impossible to evaluate.

The remarkable difference with previous studies of critical thinking is that the TTM distinguishes logical thinking and critical thinking clearly. The logical thinking of the TTM is selecting elements, finding relationships, and remaking models. It does not include evaluation. The critical thinking of the TTM is evaluating critically. It does not include selecting elements, finding relationships, and remaking models. When the models of situation are remade by logical
thinking, critical thinking evaluates them immediately. When the result of evaluation by critical thinking is "incorrect", the models will be re-remade by logical thinking.

The confusing point to be noted is that logical thinking and critical thinking also will often require the skill of logic. In the TTM, the skill of logic is only one of the means. Logical thinking uses logic in order to remake models and critical thinking uses logic as one of the standards to evaluate. For example, a computer program is output of logical thinking and a result of inspection of a computer program is output of critical thinking. Programing and inspection both need the knowledge of programming language and computer algorithm. They are equivalent to logic on logical thinking and critical thinking.

Lateral thinking

Lateral thinking is a thinking skill to generate many sorts of ideas suggested by de Bono (1967). The point of lateral thinking is that many problems require a different perspective to be taken in order to solve them successfully (Procter, 2010, p. 145). De Bono does not defined lateral thinking clearly. However, there are a lot of explanation and examples about lateral thinking in some literatures (e.g., de Bono, 1967; 1970; 1971; 1990; 1992). According to them, it can be concluded that lateral thinking has three concepts; change of cognitive patterns, humor, and future-oriented. The output of lateral thinking is unique ideas. The change of cognitive patterns will be directly reflected in the output. De Bono did not express how the humor and the future-oriented function, however, it may be said that they are some sorts of viewpoints and attitudes which are required in order to find out a pattern change. In addition, Kotler and de Bes (2003, Japanese translation edition, p. 92) said that lateral thinking is the way of thinking which changes models. It can be seen from the above that the change of cognitive patterns is the key element of lateral thinking.
It follows from what has been said that the definition of lateral thinking here is "the thinking skill for producing the patterns not to come up with in the commonsense recognition patterns." The example of lateral thinking is shown in Figure 4.

The input is "1+1=?". A figure of a window is produced by lateral thinking as an output. If using logical thinking, the output will be "2". If using critical thinking, the output will be "NG!"

Process model of the TTM

Figure 5 is the process model of the TTM.
Input is the trigger to start up creativity. It may be a very confusing problem that is very difficult to solve. Output is the result produced by creativity. It may be a solution plan. The arrows show the transfer of the process. The circles show input/output parameters between three ways of thinking. For instance, the model, the output of logical thinking, is also input of critical thinking and lateral thinking. For critical thinking, it is an evaluation object. For lateral thinking, it is a basic pattern to change or produce other unique patterns. The result of evaluation, the output of critical thinking, is also input of logical thinking and lateral thinking. If it is "NG!", logical thinking must remake model and lateral thinking has to produce another idea. The idea, the output of lateral thinking, is also input of logical thinking and critical thinking. Logical thinking reorganizes it logically to the specific executable plan. For critical thinking, it is an evaluation object. The process changes during three ways of thinking occur in a blink of an eye. Therefore, it is very difficult to identify that which thinking is working. Moreover, it is not always that all three ways of thinking work. Only one or two ways of thinking may work depending on the situation. It is assumed that two or three ways of thinking do not work at the same time, only one way of thinking works at once. Because of immediate change of thinking process, there is possibility to be felt that two or three ways of thinking is working at the same time.

To sum up, as the result of mutual exchanging information during three ways of thinking, some creative output can be produced. De Bono (1967; 1971) claimed that using only vertical thinking (i.e., logical thinking and critical thinking) or using only lateral thinking both cannot make people creative, lateral thinking produce unique idea and vertical thinking develops it. That is to say, the TTM, the interaction of three ways of thinking is nature of creativity.
Method

The tripartite thinking model creativity test

In order to reach the purpose of this paper, the tripartite thinking model creativity test (TTMT) was newly developed. The TTMT consists of three tests. First, the logical thinking test has two figural questions and two verbal questions. In the figural questions, participants must fill blanks with proper words in tree diagrams. In the verbal questions, participants are required to fill blanks with proper conjunctions during some sentences. The sample question is shown in figure 6. Eight blank boxes and five boxes that filled with words beforehand are arranged in tree-shape. Participants must fill eight blank boxes with proper words. When participants cannot understand the relations during five boxes, they will not be able to get right answers.

Second, the critical thinking test has also two figural questions and two verbal questions. In the figural questions, participants must evaluate whether the given figures are proper or not. In the verbal questions, participants are required to evaluate whether the given sentences are proper or not. The sample question is shown in figure 7. There is a post office, hospital, bridge, station,
and a destination is shown by the arrow in the figure. Participants cannot get a high score, if they do not point out problems properly.

Third, the lateral thinking test has four verbal questions and two figural questions. In the first two verbal questions, participants are required to answer solutions for the given fictitious troubles. In the last two verbal questions, participants must think up the new services or the products using the given words. In the figural questions, participants have to put proper words in the balloon and give a title of given pictures. The sample question is shown in figure 8. There is a cup, a clock, a pen, and a notebook on the desk. A cup has a balloon to say something. Participants are required to fill balloon with proper words and give the title of the picture.
 Participants can get a high score, if they hit upon unique and smart answer.

**Put words in the balloon and a title of the picture.**

![Image](image.png)

**Figure 8 Sample of lateral thinking question.**

In order to examine criterion-related validity, the ATTA was conducted at the same time. As explained before, all previous measures did not meet the good level of psychometric quality. However, the TTCT have been widely used by many researchers since Torrance developed it in 1996. In addition, the ATTA was developed as adult version of the TTCT. Therefore, it is judged that it is most rational to use the ATTA for examining criterion-related validity.

**Procedure**

**Participants**
The research was conducted in September, 2011. Participants were recruited from business people mainly work in Tokyo metropolitan area. The data was collected by the paper-and-pencil test. There is no lack of data. Sample size is 345. 131 are women (38.0%), 214 are men (62.0%). The age of the participants range from 22 to 62, with a mean age of 36.9 years old ($SD = 9.36$). 112 (32.5%) are 20-29 years old, 86 (24.9%) are 30-39 years old, 113 (32.8%) are 40-49 years old, 32 (9.3%) are 50-59 years old, and 2 (0.6%) are 60-69 years old. In educational level, 16 (4.6%) are graduate school educated, 314 (91.0%) are college educated, 6 (1.7%) are junior college educated, 6 (1.7%) are professional training college educated, and 3 (0.9%) are high school educated. In employment status, 5 (1.4%) are corporate officer, 314 (91.0%) are employee, 3 (.9%) are staff of public institution, 15 (4.3%) are self-employed or freelance, 4 (1.2%) are housewife, and 4 (1.2%) are unemployed. Mean length of service is 14 years ($SD = 9.18$). This describes that data was collected from the layer which has a comparatively rich social experience.

Results

Reliability

All four questions of the logical thinking test have right answers. The perfect score of question I-1 and I-2 in figural is eight points, question I-3 is three and I-4 is five in verbal. Mean score of I-1 is 6.98 ($SD = 1.25$), I-2 is 7.70 ($SD = .52$), I-3 is 1.86 ($SD = .83$), and I-4 is 3.93 ($SD = 1.03$).

All four questions of the critical thinking test are the free describing form questions that do not have right answers. According to the scoring manual, answers are graded by three raters independently, two are experts of the personnel affairs assessment and the remainder is a graduate school student major in creativity. The perfect score of all four questions are six points. Mean
score of II-1 (figural) is 3.04 ($SD = 1.67$), II-2 (figural) is 2.78 ($SD = 1.47$), II-3 (verbal) is 3.46 ($SD = 1.49$), and II-4 (verbal) is 2.19 ($SD = 1.05$). The reliability of the critical thinking test is examined by inter-rater reliability. Mean correlation coefficients of three raters are that II-1 is .918, II-2 is .889, II-3 is .888, II-4 is .873, and total is .892. Therefore, they show sufficiently high reliability.

As well as the critical thinking, all six questions of the lateral thinking test are the free describing form questions that do not have right answers. Answers are graded by three raters independently according to the scoring manual. The perfect score of all six questions are nine points. Mean score of III-1 (verbal) is 5.06 ($SD = 2.04$), III-2 (verbal) is 5.84 ($SD = .67$), III-3 (figural) is 3.92 ($SD = 1.49$), III-4 (figural) is 4.19 ($SD = 1.53$), III-5 (verbal) is 3.39 ($SD = .87$), and III-6 (verbal) is 3.44 ($SD = 1.03$). Likewise, the reliability is examined by inter-rater reliability. Mean correlation coefficients of three raters are that III-1 is .847, III-2 is .561, III-3 is .737, III-4 is .625, III-5 is .371, III-6 is .480, and total is .603. Therefore, they show good reliability. In lateral thinking test, unique answers can get high scores, however, there is few answers which meet this grade. As for the reliability, it reflects the difficulty of grading and secures minimum level.

For the ATTA, according to Goff and Torrance (2002), answers are graded by two raters independently who are experts of the personnel affairs assessment. The scores are shown as CI (Creativity Index). Mean score of CI is 139.05 ($SD = 22.27$). Correlation coefficient of two raters is .928.

Validity

Construct validity

Construct validity was examined by confirmatory factor analysis (CFA) as shown in
Figure 9 and Table 2. "LOT" means logical thinking, "CRT" means critical thinking, and "LAT" means lateral thinking as the latent variables. The LOT has four observed variables; the score of the logical thinking questions (i.e., I-1, I-2, I-3, and I-4). The CRT has four observed variables; the score of the critical thinking questions (i.e., II-1, II-2, II-3, and II-4). The LAT has six observed variables; the score of the lateral thinking questions (i.e., III-1, III-2, III-3, III-4, III-5, and III-6). There is a latent variable, "Creativity", on three latent variables. The values on each arrow are standardized estimates. The values on each observed variable and latent variable are the estimated reliability.

The result of analysis is that GFI is .967, AGFI is .953, CFI is .954, RMSEA is .022, and chi-square is 86.096 (n. s.) with 74 degrees of freedom. As can be seen in Table 2, the LOT, the CRT, and the LAT influence creativity. I-1, I-2, I-3, and I-4 influence the LOT. II-1, II-2, II-3, and II-4 reflect the CRT. III-1, III-3, III-4, III-5, and III-6 illustrate the LAT. III-2 toward the LAT is suggestive (p<.10). These results show that the hypothesized model fits the data reasonably quite well.
Figure 9. Construct validity of the tripartite thinking model creativity test: standardized estimates.
Table 2. Regression weights

<table>
<thead>
<tr>
<th></th>
<th>unstandardized</th>
<th>standardized</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>estimate</td>
<td>SE</td>
</tr>
<tr>
<td>LOT ← Creativity</td>
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<td>.731</td>
</tr>
<tr>
<td>CRT ← Creativity</td>
<td>.482</td>
<td>.231</td>
</tr>
<tr>
<td>LAT ← Creativity</td>
<td>.722</td>
<td>.349</td>
</tr>
<tr>
<td>Q. I-1 ← LOT</td>
<td>.834</td>
<td>.388</td>
</tr>
<tr>
<td>Q. I-2 ← LOT</td>
<td>.316</td>
<td>.156</td>
</tr>
<tr>
<td>Q. I-3 ← LOT</td>
<td>.660</td>
<td>.281</td>
</tr>
<tr>
<td>Q. I-4 ← LOT</td>
<td>1.000</td>
<td>.354</td>
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<tr>
<td>Q. II-1 ← CRT</td>
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<td>1.365</td>
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<td>Q. II-3 ← CRT</td>
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</tr>
<tr>
<td>Q. II-4 ← CRT</td>
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<tr>
<td>Q. III-1 ← LAT</td>
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<td>Q. III-2 ← LAT</td>
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<td>Q. III-3 ← LAT</td>
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<td>.813</td>
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<td>Q. III-4 ← LAT</td>
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<td>.885</td>
<td>.303</td>
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<tr>
<td>Q. III-6 ← LAT</td>
<td>1.000</td>
<td>.261</td>
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Criterion-related validity

Criterion-related validity was examined by covariance structure analysis as shown in Figure 10 and Table 3. "Creativity", the latent variable is linked with the observed variable, "ATTA" that means "CI", by the arrow. The result of analysis is that GFI is .964, AGFI is .950, CFI is .952, RMSEA is .021, and chi-square is 100.197 (n. s.) with 87 degrees of freedom. As can be seen in Table 3, the ATTA influences creativity. The other variables are same as in Figure 10 and Table 3. These results show that the hypothesized model fits the data reasonably quite well too.
Figure 10. Criterion-related validity of the tripartite thinking model creativity test: standardized estimates
### Table 3. Regression weights

<table>
<thead>
<tr>
<th>Unstandardized</th>
<th>Standardized</th>
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<td></td>
<td>estimate</td>
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<td>ATTA ← Creativity</td>
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</tr>
<tr>
<td>LOT ← Creativity</td>
<td>1.000</td>
</tr>
<tr>
<td>CRT ← Creativity</td>
<td>.451</td>
</tr>
<tr>
<td>Q. I-1 ← LOT</td>
<td>.622</td>
</tr>
<tr>
<td>Q. I-2 ← LOT</td>
<td>.314</td>
</tr>
<tr>
<td>Q. I-3 ← LOT</td>
<td>.690</td>
</tr>
<tr>
<td>Q. I-4 ← LOT</td>
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</tr>
<tr>
<td>Q. II-1 ← CRT</td>
<td>4.019</td>
</tr>
<tr>
<td>Q. II-2 ← CRT</td>
<td>4.033</td>
</tr>
<tr>
<td>Q. II-3 ← CRT</td>
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</tr>
<tr>
<td>Q. II-4 ← CRT</td>
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</tr>
<tr>
<td>Q. III-1 ← LAT</td>
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<td>Q. III-2 ← LAT</td>
<td>.344</td>
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<td>Q. III-5 ← LAT</td>
<td>.884</td>
</tr>
<tr>
<td>Q. III-6 ← LAT</td>
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### Discussion

#### Theoretical Implications

This paper suggested the tripartite thinking model and developed the tripartite thinking model creativity test. The result of confirmatory factor analysis and covariance structure analysis leads to the conclusion that the tripartite thinking model is very valid to grasp creativity. Based on such a result, the theoretical implications of this research can argue from the both sides on the theoretical and methodological aspect. To begin with, in the theoretical aspect, the point is that new creativity definition is suggested. There is a widely agreed definition of creativity, "the ability to produce new and useful thing" in previous research. However, because two key words, "new" and "useful", have relative conception, the evaluation whether creative or not depends on
the rater's subjects, the times, and country and so on. Researchers disagree in opinion that "What is new?", "What is useful?", and "How and who does judge?" Therefore, there has not been the universal definition of creativity since the 1950s when creativity research started. On the contrary, the TTM is clearly different from the previous definition that has persisted in "new" and "useful". As a result of considering the creative process that happens in the brain of the people in detail, it is reasonable to conclude that the TTM established a universal creativity model.

Finally, in methodological aspect, the point is that new creativity measurement, the TTMT, was developed and the consistency between the TTM and the TTMT was verified. There are two differences between the TTM and the previous measurements. The first is the strength of interpretability of the measurement. For instance, TTCT/ATTA measures divergent thinking. Divergent thinking is only a part of creativity (Runco, 1993; Plucker and Makel, 2010), therefore, there is possibility that TTCT/ATTA cannot measure whole creativity. Conversely, the TTMT measures three ways of thinking, logical thinking, critical thinking, and lateral thinking based on the TTM. That means that it is able to grasp creativity by using the TTMT. The second is that whether the data of reliability and validity are shown clearly. For instance, there is reliability data of the TTCT based on KR21 in Torrance (2008b), however, there are not shown the data collection procedures, sample size, and attributes of participants. In addition, as for the validity data, it isn't shown at all. By contrast, this paper showed the reliability and validity data of the TTMT. As for reliability, the data of inter-rater reliability is shown in the critical thinking test and the lateral thinking test. The data of the construct validity examined using by confirmatory factor analysis (CFA) supports strongly the fitness of the TTM and the TTMT. Additionally, the data of the criterion-related validity examined using by covariance structure analysis showed that the TTMT fits the ATTA reasonably quite well. The fact that even TTCT/ATTA which is regarded as representative creativity test cannot show the data of reliability and validity reveals that this
Practical Implications

This research has two practical Implications. First is that the answer for "What is creativity?" is suggested. It is obvious that creative people are needed at the present time when our environment is intensely changing, however, there is no discussion about what are creative people specifically. If the specific image of the creative people is not shown, it is impossible to find creative people.

The second is that the TTMT made possible to develop new training program of creativity. The TTMT is the tool to measure creativity at some time. However, it will be possible to catch the amount of change of creativity by using the TTMT repeatedly after certain period. That also means it will be possible to know the effect of the creativity training and what sort of experience does the creativity improve. To argue creativity training would be beyond the scope of this paper, however, the TTMT will contribute to the development of finding and training creative people.

Future Research

Three problems are left in this research. For one thing, more questions of the TTMT should be developed. There are only four questions in the logical thinking test and the critical thinking test, six questions in the lateral thinking test. However, a lot of questions that have many sorts of degrees of difficulties are needed, in order to use the TTMT repeatedly and measure creativity of many classes of people. Additionally, each question should have appropriate difficulty.

What is more, the method for automating grading the answer of the TTMT is should be
developed. In the critical thinking test and the lateral thinking test, answers are graded by three raters independently. It takes about six days per one rater to grade 345 participants' answers. In the way of the present grading method, it takes too much the time to get much more data.

One final point is the development of the web version TTMT. In this research, the TTMT was conducted by the traditional paper-and-pencil test. The web version TTMT will make possible to get much more data from many sorts of classes. In addition, it will become possible to trace the process of answering of participants', therefore, it will be expected to be able to analyze the process of three ways of thinking multilaterally.

In this paper, the TTM and the TTMT are suggested. These are what we call "lateral definition and lateral measurement of creativity." This is challenging suggestion because it deviates from the discussion of previous creativity studies. However, it is believed that it is necessary to discuss from the different viewpoint to achieve further development. It is hoped that the outcome of this paper will contribute to a better understanding of creativity.

References


Kaufman, J. C., & Baer, J. (2012). Beyond new and appropriate: Who decides what is creative?


