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Doctoral Thesis

Affective Experience and Creative Group Activities in High Educational Learning Context

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Abstract

The requirement of creativity and working collaboratively in future jobs are arising. The concern on the connection between creativity and affective experience has proceeded from the individual level to the group level. This dissertation aims to investigate the relationship between affective experience and creative group work, particularly in a high educational learning context. This dissertation discusses the connection between affective states and creative performance, and the effect of creative work on affective state.

This dissertation included three studies conducted in creative group projects. The first examined how the affective aspects of group members correlated with the creative group performance of tasks. This empirical research collected data over the course of five class meetings during which the participating students accomplished the performance of seven tasks and shared their perceptions with regard to the affective state. The results showed coherence between the performance of divergent tasks and the emotions of participants, especially in terms of the psychological state of arousal. This study also discussed the involvement of leadership factors in creative group work experience.

The second study investigated how the ordering of divergent and convergent tasks during the creative process influences changes in the affective experience. Groups of students were each assigned to classes with different pairings of divergent and convergent tasks: either convergent tasks in a series, a divergent task followed by a convergent task, a convergent task followed by a divergent task, or two divergent tasks performed in a series. The subjects' affective states were measured before and after each task, and valence and arousal levels were compared to derive

changes in affect. The results showed that the participants' affective states were raised most significantly in the divergent process.

The third study investigated how the type and order of creative tasks may influence the affective states and group work satisfaction of people engaged in creative group work. Groups of participants performed two kinds of conventional creative tasks of divergent and convergent in two different orders. The affective states and group work satisfaction were measured repeatedly after each of the two tasks. The results show that the convergent task produced a more positive effect on the affective state and group work satisfaction than did the divergent task. The second task induced a higher valence than the first task. This study provides a better understanding of the design of creative group tasks to yield better affective experiences.

To conclude, in the study on affective experience and creative activities, creative group work differed from individual creative effort in relation to affects. The psychological state of arousal involved more in the group work. The different types of tasks and the orders should be considered in executing the creative processes in a group.

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Glossary of Writing Terms

Affective change: the alteration of the affective state, in the form of increasing, decreasing, or stable, before and after conducting an activity. It indicates a dynamic affective level.

Affective State: the level of emotion or mood captured in a point of time.

Creativity: cognitive abilities to be scaled up through a learning process and a basic skill for problem-solving.

Creative activities: various kind of creative task or work either as part of the learning process (e.g., brainstorming, storytelling) or conventionally known as creative task (e.g. alternate uses test).

Group creativity: creative activities performed by several people in a group.

Learning: efforts to acquire new knowledge and expertise, in this dissertation related to creativity.

Performance (measure): the achievement toward creative activities expressed by creative scores. What group members express and display during the creative activities were assessed according to the creative criteria of each task (i.e., divergent or convergent). For the complexity of the criteria, the assessment involves both objective and subjective criteria.

Problem-solving: efforts to accomplish cases that, in this dissertation, requires or permit novelty, systematically through a creative process approach.

Satisfaction: an affective expression toward creative activities and group performance (see *group work satisfaction* in **Chapter 4**).

Chapter 1. Introduction

1.1 Research Background

The escalation of the demand for creativity is hard to avoid (Wronska, Bujacz, Gocłowska, Rietzschel, & Nijstad, 2019). Creativity appeared in everyday life, art, social interaction, education, public policy, and business (Moran, 2010) is becoming more evident today. Nowadays, social media has sped up the need for creative content. Every business seeks to produce stand out products and promotion in a fiercely competitive environment. Similarly, the World Economic Forum (2020) has stated that creativity is one of the top 15 trending skills for 2025.

Higher education is the spearhead of provision for the needs of creative human resources. Hence, higher educational institutions encourage their students for creative thinking skills through some courses and training. The learning process of creative skills involves two fundamental factors, namely person and process (Kozbelt, Beghetto, and Runco, 2010). While the process factor is rounded, the person factor is lacking particularly the affective factor. Rather, creativity as a cognitive process may influence and be influenced by the affective state (Akbari Chermahini & Hommel, 2012).

Furthermore, businesses in every sector require collaboration between people. Working collaboratively in a group is not only to elevate creativity skills (Davies et al., 2013) but also to solve complex problems in practical ways. Hence, besides cognitive skills, people need non-cognitive skills (i.e., social skills). Again, the social skill demands understanding of the affective factor. Hence, higher education teachers need an understanding of how affective and creativity works together and to deliver the skill to their pupils. The knowledge of the interaction between creative process and human's affective state in a group work is significant to support the performance and creative sustainability.

1.1.1 Creativity concept

American Psychological Association (n.d.) defined creativity as "the ability to produce or develop original work, theories, techniques, or thoughts." In the context of cognitive abilities, creativity is defined as "the ability to come up with unusual or clever ideas about a given topic or situation, or to develop creative ways to solve a problem" (World Economic Forum, 2016). While the earlier study attached creativity to the individual characteristic (Guilford, 1950), more recent studies expanded the focus of creativity in two ways, namely, creative outcome and creative process (Davis, 2009). Amabile (1983) identified creativity conceptually as a novel and appropriate outcome that results from a heuristic process rather than an algorithmic one. In terms of process, creativity primarily consists of problem finding, ideation, and evaluation (Runco & Chand, 1995). Problem finding includes preparatory behaviors for determining the scope of the problem to be solved. Meanwhile, ideation and evaluation are used to achieve both standards of creative outcomes, i.e., novelty and usefulness (Davis, 2009). Here, we consider creativity as the cognitive abilities to be scaled up through a learning process, and we posit that the cognitive theories of creativity are a primary concept for problem-solving.

The cognitive theories focus on process, i.e., creative thinking based on cognitive mechanisms, and person, i.e., whoever is involved in the creative process with their own characters (Kozbelt, Beghetto, and Runco, 2010). The theories classify the creative process into two, namely divergent thinking and convergent thinking. The divergent task is associated with ideation. Ideation is a process to produce fluence, flexible, and original ideas (Runco and Chand, 1995). Fluency is determined from a number of ideas generated, flexibility means varieties of ideas, and originality denotes unique or novel ideas. The ideation process is the most salient and relevant approach to the creative process (Davis, 2009). Meanwhile, the convergent thinking is significant

in the evaluation process. The evaluation process is often hidden from the creative process. However, this process fulfills the usefulness criteria in creative outcomes while involving the originality factor during evaluation (Runco & Chand, 1995). The process leads to the selection of one promising solution through an analytical process of looking for similarities, patterns, and relations of information (Ashton-James & Chartrand, 2009; DeYoung, Flanders, & Peterson, 2008; Knörzer, Brünken, & Park, 2016).

1.1.1.1 Creative task

As mentioned above, the cognitive theories determine creativity being divergent and convergent thinking. The theories asserted the significance of distinguishing creative activities into the two groups, and to assess them accordingly (Plucker & Makel, 2010). Sketches Task, Alternate Uses, Match Problem of Guilford (1967) and Torrance Tests of Creative Thinking are some of prior divergent thinking activities. Meanwhile, Remote Associates Test (Mednick, 1962) is commonly known as convergent thinking activity.

On the application, creativity is required to accomplish problems that permit newness (Runco & Sakamoto, 1999) or event require ingenuity and innovation, which is known as creative problem solving. This type of problem solving also involves divergent thinking ability to engender ideas and convergent thinking to appraise the notion (Politis & Houtz, 2015). Ideas generation is exerted through some activities such as brainstorming, while ideas evaluation applies “planned strategies and tools” (Politis & Houtz, 2015). To solve a problem, combination of alternating divergent and convergent thinking tasks is often conducted as a series of tasks (Jaarsveld & Lachmann, 2017). Yet, both ways of thinking might also conflate in a task such as The Creative Reasoning Task (Jaarsveld & Lachmann, 2017), in which divergent and convergent thinking performance are assessed severally.

Divergent thinking activities might be assessed under the criteria of fluency, originality, flexibility, and elaboration (Plucker & Makel, 2010). Meanwhile, convergent thinking assessment might adopt an associate test of creativity, which contains three factors, i.e., serendipity, similarity, and mediation (Mednick, 1962). Serendipity considers work to be associative if solutions occur accidentally through contiguous environmental appearance. Similarity assumes that work is associative if it has like elements or comparable stimuli that expose the elements. Mediation regards work to be associative if it is evoked through mediation, connection, or via a linking of common elements.

1.1.1.2 Creative group work

As the increase of problem-solving demands to produce innovation, group or team creativity has been discussed more nowadays (Paulus & Nijstad, 2003). New things might emerge from the collaboration between parties is the primary notion of researches in group creativity (Sawyer, 2010). Beside different perspectives for various background such as in education, culture, experience, and expertise, Sawyer (2010) pointed that a group work can produce "collaborative emergence", new things that arise impromptu, through improvisation, during group members' interaction. The emerging idea cannot be claimed to belong to someone.

In the divergent thinking activities performed in a group, all members are expected to share their thoughts and ideas about a certain case as much as they can, without judgment. As time goes by, they can build ideas upon their partners' and trigger other members with new ideas with quick iterative process. The ideas might be expressed through verbal, written, figure, action, or even object.

In group convergent thinking activities, members assess ideas and decide one for the final product or several for further processing. The analytical tools such as classification, finding pattern,

or reasoning can be used in evaluation. They need to choose an interesting, promising, and peculiar notion, and describe it in more detail and directed. Group members are expected to express their consideration, perception, and or strengthen others' opinion on potential ideas. At every end of the process, the group supposed to come to a consensus.

The common question concerning group creativity is how to enhance creativity of team performance, particularly in organization (Hoever, van Knippenberg, van Ginkel, & Barkema, 2012). However, because our concern is on the learning of creative processes, creative group work in this dissertation refers to some creative activities or processes that are performed in a group.

1.1.2 Affective concept

1.1.2.1 Affective state

Many terms are used to express affect such as feeling, sentiment, emotion, mood, and affective trait. Rosenberg (1998) classified affective terms into 3 levels of analysis, namely affective traits, moods, and emotions. Affective traits are described as the longest duration of affect, the most permeating in influencing consciousness, and the broadest in influencing cognitive and behavior of a person. Moods remain in an intermediate duration, influencing consciousness according to mood lability, and mediately influence one's cognitive and behavior. Emotions are the shortest remaining state, intensively change in conscious experience, and the narrowest in influencing cognitive and behavior.

In this dissertation, we use affective state and emotion term, interchangeably, to express student perception during and after performing creative activities. There is no certain distinction between moods and emotions. Moods and emotions are sensitive toward activities and the both affect term can be expressed as affective state (Rosenberg, 1998).

People may perceive various kinds of affective state such as happiness, anger, boredom, and fear. Varieties and complex mechanisms in the states cause the assessment and identification of affective states need to be simplified. The primary approach to determine the affective state is by two-dimensional states, i.e., valence and arousal (Russell, 2003). Valence shows the level of pleasure that ranges from positive to negative valence. Meanwhile, arousal level is ranged from high activation to low activation.

1.1.2.2 Group affective state

Bartel and Saavedra (2000) notion that an affective state can be valued as a group state when some people collaborate in a group work. They revealed that members in a group perceived similar (if not the same) affect due to interdependence, perpetual membership, and social norm that control members' expression. Collins, Lawrence, Troth, and Jordan, (2013) pointed that group affective states emerge from processes of individual factors (e.g., gender, age, emotional intelligence) and group factors (e.g., group affective norms, team task). These input factors are processed in two ways, i.e., bottom-up and top-down process. Bottom-up includes primitive emotional contagion, behavioral entrainment, empathy, and affective interpersonal influence. Top-down includes attraction-selection-attrition and socialization.

Bartel and Saavedra (2000) disclosed that the average of self-assessment can represent group affective state. They found positive correlations between average individual affective states and observed group affect scores. The average affective state of individual assessment is associated with group performance (Kelly & Barsade, 2001). Hence, affective experiences discussed in this dissertation are both unseparated individual and group affective state. We defined group affective states as the level of valence and arousal that group members felt during their group work, as represented by the average of individual self-assessment.

1.1.3 Creativity and affective relationship

Previous studies have explored how affective states may influence creative performance. Creativity is mostly supported by a positive affective state (Isen, Daubman, & Nowicki, 1987; Zenasni & Lubart, 2002). However, it is also known that the type of task regulates this effect (Davis, 2009; Zenasni & Lubart, 2011). A positive affective state may support divergent thinking tasks to create a number of new ideas, while a negative affective state might be beneficial in convergent thinking tasks to decide on the best idea for a solution (Newton, 2013). This notion has been proven empirically in relation to various kinds of divergent and convergent tasks, from traditional creative tasks such as the alternate uses test and the remote associates test (Lewis & Lovatt, 2013) to realistic creative problems such as developing ideas for a name of a kind of rice (Yamada & Nagai, 2015) and strategies to increase cell phone sales (Politis & Houtz, 2015).

In terms of the two dimensions of valence and arousal, the discussion of valence on creative work is more dominating than arousal. However, valence level was often discussed on a par with arousal level regarding creativity. Hence, Baas, De Dreu, & Nijstad, (2008) assumed that high valence and arousal were associated with high creativity.

Conversely, creative tasks induce a more positive affective state than do non-creative tasks (Bujacz et al., 2016). The degree of enhancement may also depend on the type of creative task. Performing divergent tasks shifted the affective state positively, while performing convergent tasks reduced positive affective state (Akbari Chermahini and Hommer, 2012).

1.2 Objective of The Dissertation

Studies investigating the relationship between creativity and affective experience are rather limited. First, most of the studies on affective states and creativity have been performed at the

individual level. In practice, however, creative activities are widely conducted in groups to solve real problems, especially in organizations (Grawitch, Munz, Elliott, & Mathis, 2003). Creativity in group work is known to be influenced by cognitive and social factors (Paulus & Nijstad, 2003). Paulus and Nijstad (2003) also implied that people face work environments, intentions, and motivations that differ when performing creative tasks in groups rather than individually. Accordingly, we expect that group work might induce different relationships between affective state and creativity, hence to be investigated.

Second, the sequential process in a creative process has often been neglected. Most of the previous studies evaluated the affective state in a single task. However, to solve a problem, creative activities are often conducted as a series of tasks, combining alternating divergent and convergent tasks (Jaarsveld & Lachmann, 2017). The effect of the earlier task might be carried on to the following task. The task order factor may give us information about the dynamic effect of sequential tasks on the affective experience (Trask & Sigmon, 1999). Thus, we need to examine the impact of the creative task order on affective experience. We might gain a potential intervention to manage when certain creative tasks should be performed.

The main purpose of this dissertation is to investigate the relationship between affective experience and creative process in group learning. Toward the purpose, we develop our research based on the notion of the reciprocal interaction between the affective state and creative task:

- To investigate the association between affective state and creative performance during group activities. In particular, we examine the connection between positive and negative affective experience with the score of divergent and convergent performance in group work.

- To examine the effect of creative processes of group work onto the affective experience. We focused on two factors of creative process, i.e., task type and task order. While the affective experience was regarded by the level and the change.
- To explore factors that influence the relationship of affective experience and creative performance.

1.3 Study Position and Scope of Dissertation

The effect of affective state on creative performance has been investigated for a few decades. For example, Isen, Johnson, Mertz, and Robinson (1985) and Isen, Daubman, and Nowicki (1987) examined the effect of positive induced effect on a conventional creative task performance. More recently, Yamada and Nagai (2015) and Politis and Hourtz (2015) investigated the effect of positive and neutral affect induction on the individual performance of single convergent task and divergent task. They found that positive induced people were significantly performed the divergent task better than neutral induced people.

Prior studies also investigated the association between affective state and creativity. Soroa, Balluerka, Hommel, and Aritzeta (2015) assessed the association of affective state and motivation to divergent-convergent thinking style. Zenasni and Lubart (2011) examined the correlation between the affective state and creative performance of divergent thinking and story writing. Zenasni and Lubart also assessed the effect of the creative tasks on affective state. Akbari Chermahini and Hommel (2012) focused on investigating the effect of divergent and convergent tasks on valence and arousal, while Bujacz et al. (2016) compared the effect of creative and non-creative tasks on affective experience.

Hao et al. (2015) investigated the effect of affect incubations on creative performance conducted individually in series of tasks. Amabile, Barsade, Mueller, and Staw (2005) explored the association of individual daily affect and creativity at work.

Some studies attempted to revealed the relationship between affective experience and group creativity. Grawitch, Munz, Elliott, and Mathis (2003) examined the effect of positive induced affect on performance of a divergent tasks conducted in a group. Tsai, Chi, Grandey, and Fung (2011) explored the correlation of affective state and group creativity in companies.

Build upon and extending prior research in affective experience and creativity, this dissertation takes the realm of creativity in group work. We focused on how the affect emerges in group setting and what is the correlation with creative performance. Table 1.1 describes the position of current research among literature of affective state and creativity relationship.

Table 1.1 Study position in the literature of affective state and creativity relationship

Predictor	Individual activity		Group activity	
	Static	Dynamic	Static	Dynamic
Affective state	Isen et al. (1985), Isen et al. (1987), Yamada & Nagai (2015), Politis & Houtz (2015)	Hao et al. (2015)	Grawitch et al. (2003)	
Association	Soroa et al. (2015), Zenasni & Lubart (2011)	Amabile et al. (2005)	Tsai et al. (2011)	**[This study]**
Creative task	Zenasni & Lubart (2011), Akbari Chermahini & Hommel (2012), Bujacz et al. (2016)			

We conducted our studies in higher educational learning. Higher education is a potential place to originate innovation and to develop innovative young people who for the future. Higher education encourages students to produce novel and impactful research, and supports them through various creativity courses such as art and design thinking. Hence, we expected to provide research that reflects the process of assimilation of creative abilities.

The research conducted on the creative activities carried out by the students gave several constraints. First, most of our participants were not an expert in creativity, they were heading to understand and mastery the skill instead. They had about similar educational background, at the same level of age, and in the same environment. Second, creative activities were conducted in the class within the schedule and class hours. Still, research in higher education context allowed us not only to conduct an experiment but also survey in creative classes, i.e., design thinking. We had opportunities to involve not only conventional creative activities but also case studies. The case studies arranged by course instructor were more related to daily issues instead of business purposes.

1.4 Structure of The Dissertation

This dissertation is divided into 3 main parts. The first part embraced theories on creative work in learning context and its relations with affective factors (Chapter 1). The second part conveyed studies of creative group work and affective experience relationships (Chapter 2-4). The last part discussed results of studies in general and concluded the dissertation (Chapter 5-6). Figure 1.1 depicts linkages of each chapter of this dissertation and the detail is described as follows.

Chapter 1 introduces the background of the three research in this dissertation. It elucidates existing problems about the application of creativity to higher educational learning, accordingly,

formulates the objectives of dissertation. This chapter also enclose the position and context of the studies, the scheme of the dissertation, and the contribution of the research.

Chapter 2 is a preliminary study to explore the nature of creative-based learning. It presents a set of assessments to expose the associations between group emotions and creative design performance. It also includes a set of correlation tests between emergent leadership and creative performance.

Chapter 3 observes combinations of creative tasks in the platform of the design thinking and assesses the effect of the combinations on the change of affective state. The elements of creative tasks considered in this study are the types of tasks and their orders.

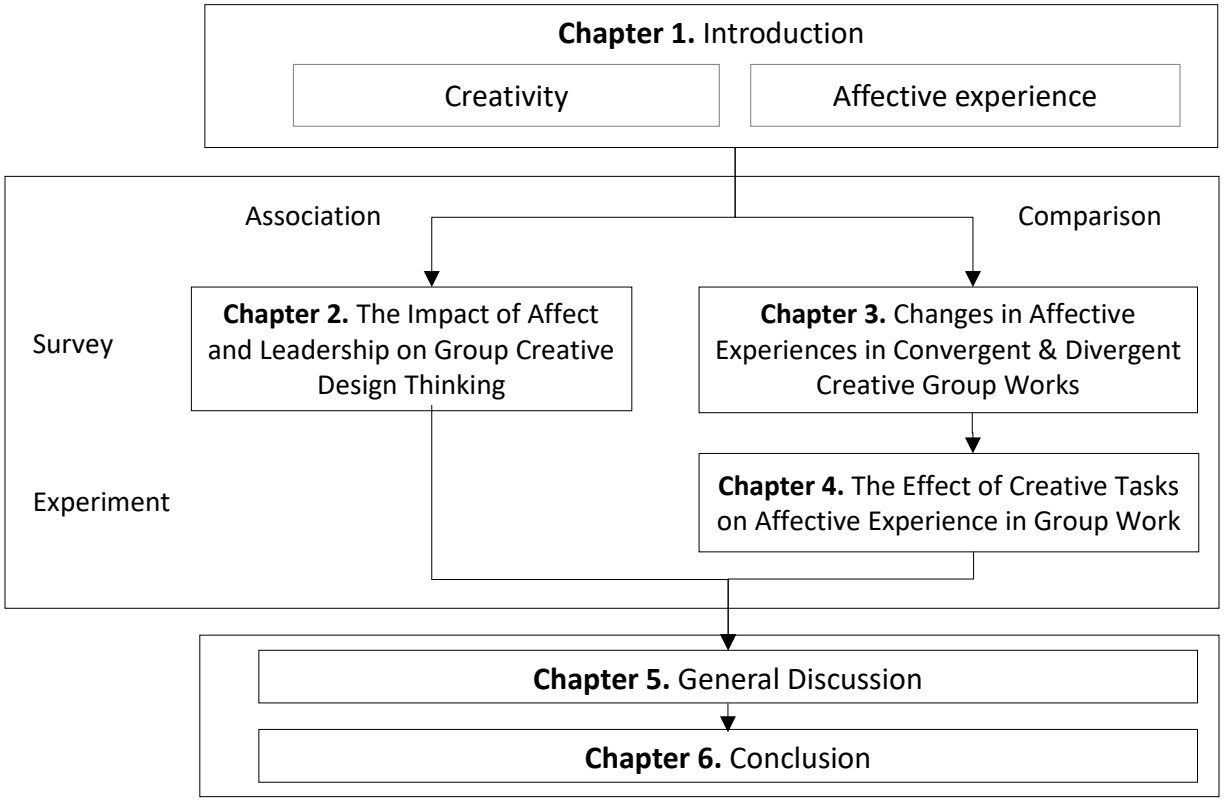

Figure 1.1 Structure of Dissertation

Chapter 4 examines further the effect of creative task types and orders on affective experience. This study applies the basic test of divergent and convergent thinking to gain a fundamental understanding of the relationship between creative process and affective state in group work. And also, the study incorporates the factor of satisfaction with group work, besides valence and arousal in affective experience.

Chapter 5 discusses general findings in this dissertation by comparing the three presented studies. Among the discussion points are the association between group creative performances and affective states and the effect of sequential creative group work on affective experience.

Chapter 6 deduces the dissertation with a summary of outcomes, contribution to teaching-learning practices and research, and limitations and envisions of future studies.

1.5 Contribution of The Studies

Studies in this dissertation proposed factors to be considered in conducting creative group work. Group work used to be applied, expecting only to enhance creativity. Although previous studies have asserted the necessary to consider about affective states in creativity, most of the goal is to find the best affective state for creativity. Without neglecting the importance of productivity, we also need to consider for the longer views. This need becomes clearer in the learning context, where the productivity is not the highest priority. It is more important to consider of how to motivate people to think creatively, to do creative processes patiently, and to collaborate with parties willingly. Because innovation requires time and persistence. Motivation is the keys for long life creativity, while impression and memorable learning will be the fuel for motivation.

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Chapter 2. The Impact of Affect and Leadership on Group Creative Design Thinking

2.1 Introduction

Creativity is regarded as mandatory in our everyday lives. People are always asking for something fresh and new and seeking joy in every aspect of life. Therefore, the designers who formulate a service or product need creativity not just to win competitions but also to sustain their existence. However, creativity cannot necessarily be stimulated as required; it requires a supportive environment (Brown, 2009).

Within the work system, a designer is often a part of a team that grows innovative ideas (Tsai, Chi, Grandey, & Fung, 2011). Both teamwork and originality are challenges that may confound a designer's emotions. Norros (2014) mentions that the human factor must also be factored into the management of a design process. Understanding the emotional attribute of designing and learning how to drive it can help support creative performance.

The emotional state appropriate for innovation is debatable. Numerous researchers have identified that positive emotions such as happiness and enjoyment serve creativity (e.g., Yamada & Nagai, 2015). However, several researchers have disputed this assertion and have found conflicting results (e.g., Kaufmann, 2003). While positive emotions could be useful in generating ideas (divergent thinking), they may confound decision making (convergent thinking). On the other hand, De Dreu, Baas, and Nijstad (2008) have demonstrated that the activation level is linked to more creativity. The elucidation of the relationship between various emotions and creative processes, especially in a group, requires in-depth investigation. A superior understanding of the affective states that support creative processes may assist in a better organization of a creative environment.

The performance of group work is another measure that can be taken to improve creative output. Brown (2009) has noted that a creative group should not be asked to pursue efficiency as its primary function because the focus on performance may hold back the release of ideas. Therefore, it is unnecessary to assign a team leader to maintain the diversity and equality in a team. However, Williams and Yang (1999) claim that the existence of a good leader is as necessary to foster creativity by providing a free environment. A leader can manage group emotions (Humphrey, 2002) and can help to maintain a cooperative and collaborative climate. The emergent leader who arises unavoidably might be able to promote a creative work atmosphere and may thus increase the group's creative performance. However, the extent to which the emergence of a leader supports (or conversely, prevents) creative performance is not yet clarified.

Research conducted on an actual project may provide insights into the varied processes faced by a designer. The discrete activities of divergent and convergent thinking can be observed. Thus, the relationship between affect, leadership, and creativity may be examined more thoroughly as opposed to the observation of a single conventional creative task such as brainstorming. The present study thus investigated the role of affect and emergent leadership on a creative design project. For every task that was accomplished, the performance of the groups was compared along with the affect state and leadership perception of the group members. The results of the comparison were assessed to ascertain how affect and leadership influenced creativity.

2.2 Theoretical Background and Hypotheses

2.2.1 Divergent-convergent thinking in creativity

Two primary processes are conducted in creative design. Although these may work separately, they interlace in the creative process. The first is divergent thinking, a necessary

process for an ill-defined condition (Jaarsveld & Lachmann, 2017). Divergent thinking involves the ability to search broadly for information problems (Ashton-James, & Chartrand, 2009; Lee & Therriault, 2013; Sternberg & O'Hara, 1999) and it is aligned with defocused thought, the default mode of a brain network. Therefore, it yields spontaneous and self-generated cognition (Jaarsveld & Lachmann, 2017) with minimum effort (Runco, 2010). Divergent thinking is characterized through flexible (Lewis & Lovatt, 2013), intuitive, fluent, and holistic expressions (De Young, Flanders, & Peterson, 2008). It is similar to associative thinking (De Young et al., 2008) and heuristic processing (Knörzer, Brünken, & Park, 2016).

The second process is convergent thinking, which is performed for a well-defined problem (De Young et al., 2008). Convergent thinking operates in focused or analytic modes of thought and yields improvement, change, and restriction (Jaarsveld & Lachmann, 2017). The process runs linearly, logically, and systematically, applying rules toward a solution (De Young et al., 2008; Lee & Therriault, 2013). It looks for similarities, patterns, and associations in information (Ashton-James & Chartrand, 2009).

Divergent thinking outcomes become material for the convergent thinking process and vice versa. Thus, distinguishing a task as resulting from either divergent or convergent thinking is complicated (Jaarsveld & Lachmann, 2017). Convergent thinking helps in restructuring problems by determining defects and verifying initial or new formulations, while divergent thinking functions to discover the elements and structure of new formulations (De Young et al., 2008). For the purposes of this study, divergent tasks refer to assignments that require more divergent thinking traits, and convergent tasks indicate those that demand a greater involvement of convergent thinking features.

2.2.2 Group emotion in creative process

Focusing on the process of group project design, the current research used group emotions to assert the group's general mental state interchangeably with affect and mood. Group emotion is a combination of the affective states of the team members, which can then re-affect the emotions of individual members (Kelly& Barsade, 2001). Group emotion can be measured by averaging the emotional perceptions of individual members (Bartel & Saavedra, 2000).

Forgas (1995) noted that emotions influence judgment mostly in two conditions: in devising solutions, a task associated with convergent thinking; and in dealing with quick, global, and simplified decisions that are assumed to involve divergent thinking. Both conditions are supported by different emotions (Collins, Lawrence, Troth, & Jordan, 2013) and may be influenced by pleasure (valence) or activation (stimulation) levels.

Valence indicates an emotional state that ranges from positive (pleased) to negative (displeased). People with positive emotions have broadened scopes of attention and spend less time fixating on information (Knörzer et al., 2016; Newton, 2013). Positive emotions encourage flexible thinking and thus help generate new, unconventional, and atypical ideas (Yamada & Nagai, 2015). People with positive emotions tend to create many solutions (Newton, 2013; Politis & Houtz, 2015). Therefore, positive emotion is generally associated with divergent thinking.

However, the above notion might not apply consistently to group work. In a group task, an individual is constrained to share something that other people may not understand or appreciate (Runco, 2010). Discrete ideas can lead to the minimizing of mimicry and threaten group harmony (Ashton-James & Chartrand, 2009). Thus, positive group emotions might hinder divergent task performance. Still, positive group emotions might also denote a comfortable atmosphere within

which ideas may be developed. Therefore, none of the members hesitate to offer their thoughts (Collins et al., 2013).

On the other hand, positive emotions can suppress convergent thinking (Knörzer et al., 2016). When people are in a positive mood, they tend to make rash judgments, are less critical, and commit more errors (Politis & Houtz, 2015). Conversely, negative emotions may facilitate a more profound understanding through narrowed attention (Knörzer et al., 2016). The fact that people spend a longer time on relevant information when they are in a negative emotional state may imply that displeasing affects accompany cognitive activity and analytic processing that is careful, systematic, persistent, and concerned with details to produce a well contemplated solution (Knörzer et al., 2016; Newton, 2013). Collins et al. (2013) claim that this concept is also applicable to group work. Members who are relatively charged with negative emotions would form a group that is more focused on the best performance of a convergent task.

In psychological terminology, the state of arousal denotes an excited-calm feeling, or an alertness to information with regard to importance or urgency (Zadra & Clore, 2011). The arousal rate ranges from high to low and guides attention so that people tend to be drawn to objects that are stimulating. Since the 1900s, researchers have investigated the role of arousal in learning and motivation. The Yerkes-Dodson law (Teigen, 1994) is a well-known theory that depicts performance as forming a curvilinear line along with the escalation of arousal (Broadhurst, 1959).

The level of arousal has been associated with other variables such as task difficulty, complexity, and novelty (Teigen, 1994). These variables are known to be challenges for creative work. The duality of mind conceptualized by Imbir (2016) assumes that increase in arousal would improve performance in a heuristic cognitive process, while a decrease in arousal would be beneficial for a rational mind, later resulting in the higher performance of the systematic cognitive

process. This notion is also supported by Finch, Peacock, Lazdowski, and Hwang (2015). They researched a business course with more convergent tasks and found that better-performing students could regulate their emotions to balance of positive-negative affects with a lower emotional tone. In congruence with the Yerkes-Dodson law, Newton (2013) asserts that the capacity for complex thought increases with the arousal level, but only up to a point, after which the intensification of arousal takes mental resources away from the task. Imbir (2016) proposes that maximum performance is associated with moderate (but rather high) arousal.

2.2.3 Emergent leadership to manage group emotion

Emergent leaders are one or several group members who influence the initiative of other members and provide value for a team (Pescosolido, 2005). Such leaders have no formal power to punish or reward group members. They tend to persuade and to provide examples rather than to order. Pescosolido (2005) states that emergent leaders often appear in ambiguous situations. They control a group's emotion and influence the interpretations made by group members and direct their reactions to events. Generally, leaders exhibit two approaches in controlling their groups (Northouse, 2016). The first involves setting a group's goal, developing strategies, and giving feedback on performance using their knowledge and experience. This tactic is used by people with task-oriented leadership (TOL). TOL people offer ideas, opinions, and information, and manage team progress by questioning, confirming, and collecting suggestions (Schneier, 1978). Therefore, they perform best in highly structured tasks (Pescosolido, 2005). TOL people often neglect the effects of their group members and may even seem harsh in their desire to accomplish their goals, but overall, they are respected by their group members (Fiedler & Chemers, 1984). Hence, people with TOL tend to maintain an emotionally neutral (Humphrey, 2002).

The second approach to leadership involves building trust with regard to the feelings of other group members and unifying the group (Pescosolido, 2005). This method is supported by the leader's ability to express emotion, to understand the emotions of others, and to persuade. These traits are witnessed in relationship-oriented leadership (ROL). They extend support, offer friendly advice, and are cheerful and accepting. They demonstrate emotions, they are domineering, and they offer criticism (Schneier, 1978). Pescosolido (2005) notes that ROL function best in unstructured tasks. They encourage group members to participate in decision making and to offer new ideas or different methodologies. They like developing good personal relationships with others (Fiedler & Chemers, 1984). The ROL people, in general, displays positive emotions (Cogliser, Gardner, Gavin, & Broberg, 2012).

2.2.4 Hypotheses

This study aimed to investigate the associations between group emotions, emergent leadership, and creative design performance. As discussed above, emotions may support the creative process. Researchers have claimed that the attribute of positive emotion is consistent with divergent thinking while the tendency toward negative emotions is suitable for convergent thinking. Since group emotions represent the contagion of the effect of the group's members, a group evincing positive emotions would represent the characteristics of a positive emotion thinker and support divergent tasks. Conversely, negative group emotions would promote deep and systematic thought processes and thus support convergent tasks. Positive group emotions may also represent a pleasurable environment in which ideas can be shared, while negative group emotions would reflect a narrow focus atmosphere which is conducive to problem solving. Therefore, the following hypotheses are derived:

H1a. A group with positive emotions achieves higher divergent task performance than a group with negative emotions.

H1b. A group with negative emotions achieves higher convergent task performance than a group with positive emotions.

Similar assumptions can be applied for the psychological state of arousal. The following hypotheses are proposed with reference to the Yerkes-Dodson law:

H1c. A group with moderate-high arousal achieves higher divergent task performance than a group with low arousal.

H1d. A group with moderate-low arousal achieves higher convergent task performance than a group with high arousal.

Finally, it is assumed that task-oriented and relation-oriented emergent leaders manage group emotions differently in supporting creative performance. According to their character traits, ROL people are more likely to possess the ability to touch the emotions of a group. They tend to express positive emotion and support a low-task structure, which is presumed to approximate divergent tasks. On the other hand, TOL express neutral emotion and should wield more control over convergent tasks. Therefore, the following hypotheses are posited:

H2a. The existence of an emergent leader evincing a relationship-oriented style (ROL) generates more positive group emotions than an emergent leader who displays a task-oriented style (TOL).

H2b. The existence of an emergent leader who exhibits a relationship-oriented style (ROL) generates higher group arousal than an emergent leader who expresses a task-oriented style (TOL).

2.3 Method

2.3.1 Study context and participants

This study was conducted with graduate majors in Industrial Engineering and Economics enrolled in a design thinking course at the Tokyo Institute of Technology. The course purposed to impart the design thinking concept and to apply it to actual problems. Practical problem solving was executed in groups. This course was deemed to represent creative design at work and was hence considered suitable for the enhancement of the researchers' understanding of group emotions in the real design process.

Seventeen students enrolled in the course (11 males and 6 females, average age = 23) participated voluntarily in this study. Seven of the students were Japanese, while the others belonged to Denmark, Thailand, Switzerland, Iran, Taiwan, Germany, China, Mexico, and India. The students were divided into four groups of 4–5 students each in an effort to maximize diversity in each group. Two students did not consistently respond to the measurement instrument, so they were excluded from all analyses. The participating students worked as a group for one semester (15 weeks).

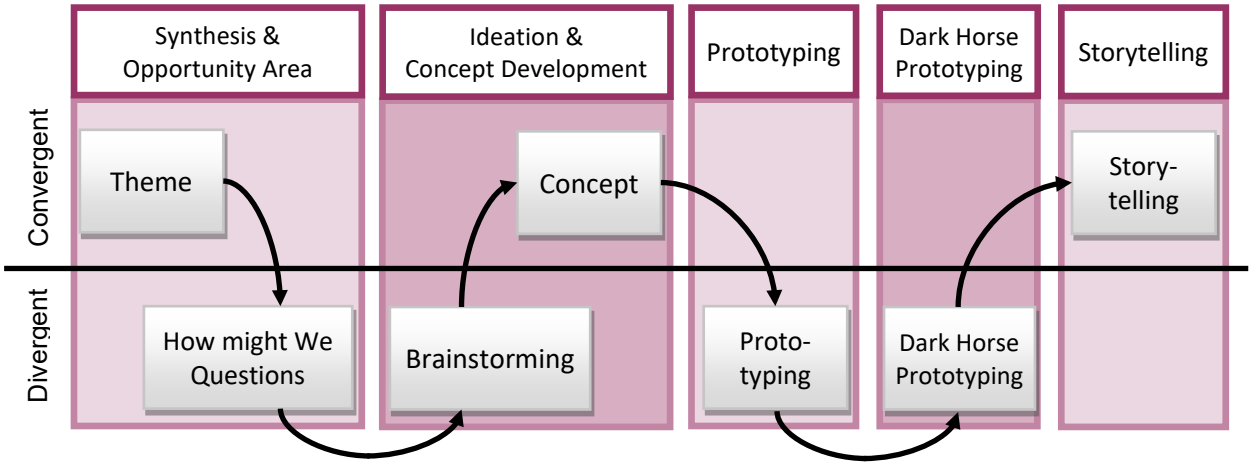

Figure 2.1 The flow of the design thinking class

2.3.2 Description of the design thinking process

A design topic was announced at the beginning of the semester and the groups were directed to follow the phases of design thinking to the postulation of a solution for their design topic. The flow of phases followed in the design thinking course were design research, synthesis and opportunity area, ideation and concept development, prototyping, business design, dark horse prototyping (DHP), and storytelling. Figure 2.1 illustrates phases investigated in this study. As stepping stones, each phase mandated the completion of one or two tasks, lasted at least two weeks. During each of the two weeks of a particular stage, students learned the concepts and methods in the first week and subsequently applied the theory in group tasks the following week.

The design process was started with the design research phase, in which it challenged students to uncover interesting insights from people in technology, service, or environment. They were asked to collect information through interviews and observation about what people say and do, and attempted to understand what people think and feel, and what exactly needs, wants, and hopes of the people. Conducting outside the class, each group had independency to arrange their strategies to collect the information collection. Basically, data was collected individually by each member, however they may also work hand in hand with peer in a group.

Information collected in the design research phases become inputs for the synthesis and opportunity-area stage. This stage produced two outcomes: theme, and how-might-we question (HMWQ). A theme was obtained by synthesizing information similar to the knowledge accrued in design research. Group members were expected to bring all information (e.g., figures, list of interesting points) to the class and stick them on the wall. They shared their information and stories within group members and highlighted keywords of each interesting information with sticky notes. After tracing all the information, they categorized the sticky notes into several groups for the

similarity and connectivity of the information, then determined themes of the groups. Based on the themes, members in group generated opportunity areas, which known as how-might-we question (HMWQ). HMWQ represented the inference of interesting problems from themes that accorded the opportunity of proposing solutions to design topics.

The period of ideation and the concept development demanded the accomplishment of brainstorming and concept-oriented tasks. Each group selected two to three HMWQ and elaborated their ideas. In teen to fifteen minutes for each of HMWQ, each group were asked to stand up and do brainstorming. With post it in hand, each group member wrote or drew his/her idea, then said while stuck it around the HMWQ, alternately. The member had to mention the idea loudly so that other members can hear and, if possible, built another idea based on it. After times up, the group discussed the ideas they come up with and identified interesting ideas. Each group selected three most interesting ideas and developed a concept for each. Group members should together define a name for each concept, then discuss and elaborate the definition, detail feature and function, and impact of each concept.

In the prototyping segment, each group visualized their concepts as a sample to facilitate them communicating their concepts with potential users. They built their prototypes with cheap and easy materials so they can make it quick and easy to be destructed. They explained their first prototype in front of their classmate, asked for feedback, and without hesitant threw it away and made a new and better prototype to be presented to potential users. Groups should also assess the feasibility of their improved concept in the business-design phase. The DHP phase was added to stimulate their ideas to challenge their previous concepts. The process was like the prototyping segment. It was just each group had to generate some extreme “crazy” ideas of their HMWQ with

quick brainstorming and make a new, easy, quick, and dirty prototyping from the most interesting idea.

In the final phase of storytelling, each group prepared a two-minute video to communicate their proposed product or service. They designed a scenario to tell what product or service they will make, why it is needed, and how it works. Apart from providing information, the stories need to provide a deep message and impression to the audience. At the last class meeting, each group representative presented their work and played the video they made.

2.3.3 Measurement

2.3.3.1 Group emotion

The emotional states were measured with self-report scale. The valences and arousal levels of the students were measured using the Self-Assessment Manikin (SAM; Bradley & Lang, 1994). Students were asked to think of the time they spent performing a task (e.g., one week for ideation and concept development), and to evaluate their emotions at that time on a 9-point scale (valence: 1 = negative, 9 = positive; arousal: 1 = low arousal, 9 = high arousal). Group emotion scores were subsequently obtained as the averages of the valence and arousal scores across members of a group. Internal consistencies, computed for the individual score and the average score, were found to be adequate (valence $\alpha = 0.62$; arousal $\alpha = 0.80$).

2.3.3.2 Creative task performance

The performance of design thinking is commonly measured by the final design of the innovative product or service proposed. The assessment is given by stakeholders, potential investors, or potential users. However, to determine the relationship between affective state and creative performance, measurement of creative performance in this study was carried out for each task.

Assessing performance of creative work is complex. The objective measures (e.g., the number of ideas that arise, the number of ideas that differ from others) were not suitable in the cases of this study. The large number of ideas does not guarantee the creativity of these ideas. Besides, comparing ideas from one group to others was inadequate because the interests of each group were different. Likewise, the choices made in convergent tasks cannot be judged right or wrong. Meanwhile, creative-not creative rating was considered too global. Hence, we adopted the subjective measures to assess divergent and convergent task performance.

The measurement of divergent tasks was adopted from Silvia et al. (2008). The subscales were uncommon, remote, and cleverness. Uncommon indicates work that occurred infrequently in relation to other tasks. Remote implied work that was distantly linked to everyday objects or ideas. Cleverness denoted work in which people were insightful, ironic, humorous, fitting, or smart. Three to five statement items for each subscale were developed and were customized for every assigned task. For example, “This question is similar to other questions” was used to measure uncommon in the synthesis and opportunity area phase. “This prototype has never existed before” was posited to assess remoteness in prototyping. “This question is challenging” was used to measure cleverness in HMWQ. Internal consistencies of the item scales for uncommon, remote, and cleverness were $\alpha = .88$, $\alpha = .60$, $\alpha = .85$, respectively. The low alpha of remote might be due to a few numbers of question items.

The measurement of convergent tasks was adopted from Mednick (1962), which indicated that creative solutions may be achieved through associative thinking using the features of similarity, serendipity, or mediation. Similarity assumes that work is associative if it has like elements or comparable stimuli that expose the elements. Serendipity considers work to be associative if solutions occur accidentally through contiguous environmental appearance.

Mediation regards work to be associative if it is evoked through mediation, connection, or via a linking of common elements. These three associative factors were adopted as subscales to examine convergent tasks. One to five statement items were developed for each subscale adopted in each task. “This concept was derived from some ideas that came up during brainstorming” is an example of a similarity statement in the concept-development phase. Internal consistencies of the item scales for similarity, serendipity, and mediation were $\alpha = .74$, $\alpha = .68$, $\alpha = .88$, respectively.

Subjective ratings that have been widely used in assessing creative products were applied (Silvia et al., 2008). Five teaching assistants assessed divergent and convergent task outcomes for all the design thinking phases. They independently evaluated each outcome for each group. Each result was evaluated according to the divergent or convergent subscale item discussed above on a five-point Likert scale (1 = highly disagree, 5 = highly agree). The average scores of the five raters were considered to be the final performance score. The interclass correlation coefficient, which is coincident with Cronbach's alpha, was measured to assess agreement across raters. The alpha of the divergent score indicated good interrater reliability for uncommonness (.82) and cleverness (.90) and minimally adequate reliability for remoteness (.62). The interrater reliability of the convergent score was .76 for similarity and .80 for serendipity, which indicated reasonable internal consistency and reliability. However, the .44 alpha for mediation denoted poor reliability.

2.3.3.3 Leadership style

Northouse’s (2016) leadership behavior questionnaire was adopted to ascertain the behavioral style of leadership as described above through twenty question items: ten odd-numbered items indicated TOL and ten even-numbered items were used to designate ROL. Five-point scales were used for this instrument (1 = never, 2 = seldom, 3 = occasionally, 4 = often, and 5 = always). Internal consistency was $\alpha = 0.939$ for TOL and $\alpha = 0.896$ for ROL.

2.3.4 Procedure

The current study focused on creative tasks conducted in groups. Design research and business-design assignments were excluded from this investigation. Design research was considered as individual task, and it was thus not representative of group work. The business-design component was only imparted in this class theoretically through a lecture and was taught in more detail in other modules. Therefore, this study encompassed five phases and seven tasks as shown in Figure 2.1.

The tasks were categorized according to their nature into either divergent or convergent thinking. The HMWQ, brainstorming, prototyping, and DHP were assumed to be divergent tasks. All these tasks expected uniqueness, reproduction, and multiple outputs to create choices within a limited time. On the other hand, theme, concept, and storytelling involved organizing, analyzing, and choosing how to approach the solution and were thus deemed to be convergent tasks.

At the end of each phase, participants were asked to complete questionnaires to assess the valence and arousal of their own emotions, and to record their subjective evaluation of the emergent leadership in their group. Each student received a form that contained the SAM and leadership questionnaire, along with a group name and user code. The group name was necessary to relate the obtained data to a particular group, while the user code was used to ensure data continuity. Raters evaluated the outcomes of each of the divergent or convergent tasks on rating sheets that were provided to them.

2.4 Results

2.4.1 Descriptive statistics

Table 2.1 summarizes the means and standard deviations (in parentheses) of affect in the groups (valence and arousal), their leadership perception (TOL and ROL), and their performances. The overall group valence scores were neutral to positive both for the divergent and the convergent tasks. The valence level changed vigorously. Group 1 and 3 experienced emotional fluctuations more than the other two groups. The valence level of Group 2 increased over time. Arousal levels in all phases unfolded from low to high. Group 1 and 4 were more aroused than the other two groups. The overall emergence of TOL was moderately low (M = 33.37), while the emergence of ROL was moderately high (M = 37.24). Group 2 and 4 consistently reported higher emergent leader scores. Group 2 exhibited the highest TOL score in all the phases. Finally, all groups showed similar performance scores in both divergent and convergent tasks and no one group was dominant.

2.4.2 Emotion and performance

Emotions and their relation to the performance of creative tasks were analyzed in three steps: first, grouped data were examined via simple comparison; the subsequent two steps were taken to obtain statistical evidence. Due to the small amount of data, statistical analyses were conducted at the individual level instead of at the group level. This emotional state differed from the individual emotion emerged in individual creative tasks. As discussed earlier, the emotional state here reflects the group emotion through the contagion and interaction among group members during group work. The second step examined the correlation between emotions and performance. The last step investigated whether the emotional level significantly differed between high- and low-performance groups.

Table 2.1 Means and standard deviations (in parentheses) of valence, arousal, relation-oriented leadership (ROL), task-oriented leadership (TOL), and performance scores by phases and groups.

						Divergent performance					Convergent performance				
Group	*n*	valence	arousal	ROL	TOL	*i*	Overall	Uncom-mon	Remote	Clever-ness	*i*	Overall	Similar-ity	Seren-dipity	Media-tion
Phase 1						Opportunity Area (HMWQ)					Synthesis (Theme)				
1	4	7.00 (1.23)	6.00 (0.71)	36.3 (5.9)	26.5 (5.9)	6	3.17 (0.47)	3.44 (0.38)	2.58 (0.48)	3.49 (0.61)	7	3.34 (0.22)	3.75 (0.39)	2.46 (0.42)	3.80 (0.29)
2	3	6.00 (1.41)	3.67 (0.47)	40.3 (2.9)	41.7 (3.1)	4	3.28 (0.28)	3.70 (0.35)	2.68 (0.25)	3.47 (0.32)	5	3.28 (0.06)	3.82 (0.62)	2.20 (0.79)	3.82 (0.31)
3	4	5.25 (1.09)	5.25 (2.49)	33.0 (6.3)	30.6 (9.3)	2	3.60 (0.26)	3.87 (0.20)	3.17 (0.23)	3.76 (0.36)	6	3.03 (0.38)	2.93 (0.58)	2.83 (0.72)	3.32 (0.52)
4	4	6.50 (1.50)	6.75 (0.43)	39.8 (1.5)	36.0 (0.7)	-	-	-	-	-	9	3.34 (0.28)	3.66 (0.78)	2.42 (0.51)	3.93 (0.25)
Phase 2						Ideation (Brainstorming)					Concept Development				
1	3	6.67 (1.25)	7.00 (0.82)	37.7 (9.9)	26.0 (5.9)	3	3.74 (0.12)	3.80 (0.25)	3.50 (0.33)	3.93 (0.12)	1	3.79	3.70	3.40	4.27
2	3	6.00 (0.82)	3.67 (0.94)	37.0 (1.4)	38.7 (3.8)	3	3.27 (0.04)	2.98 (0.08)	3.07 (0.10)	3.67 (0.04)	2	3.90 (0.13)	4.05 (0.05)	3.53 (0.28)	4.13 (0.07)
3	3	7.33 (0.47)	4.67 (0.47)	31.7 (5.4)	23.3 (3.4)	3	3.33 (0.13)	3.33 (0.43)	3.33 (0.13)	3.32 (0.16)	1	3.22	3.10	3.35	3.20
4	3	7.00 (0.82)	7.33 (0.47)	42.0 (2.8)	37.7 (4.1)	3	3.69 (0.04)	3.78 (0.22)	3.38 (0.17)	3.89 (0.04)	1	3.59	3.90	3.35	3.53
Phase 3						Prototyping									
1	4	8.00 (0.00)	5.75 (2.28)	35.8 (6.2)	28.3 (5.4)	2	3.94 (0.05)	4.00 (0.07)	3.63 (0.03)	4.20 (0.12)					
2	2	6.50 (1.50)	4.50 (1.50)	42.0 (2.0)	41.5 (2.5)	2	3.68 (0.24)	3.77 (0.23)	3.40 (0.25)	3.88 (0.24)					
3	4	5.25 (1.48)	5.50 (0.50)	32.8 (4.2)	28.8 (5.1)	1	3.47	3.67	2.95	3.80					
4	3	6.33 (2.49)	7.00 (0.00)	40.7 (3.7)	38.0 (3.6)	1	4.04	4.47	3.70	3.96					
Phase 4						Dark Horse Prototyping									
1	4	5.75 (2.28)	4.50 (2.06)	34.8 (8.0)	21.0 (7.8)	1	4.22	4.20	4.10	4.36					
2	3	6.67 (0.94)	3.67 (0.47)	42.7 (2.6)	41.7 (5.8)	1	3.89	4.13	3.45	4.08					
3	3	6.00 (1.41)	3.67 (0.47)	26.7 (7.6)	25.7 (4.2)	1	4.31	4.73	4.05	4.16					
4	3	7.33 (0.47)	6.67 (1.25)	41.3 (3.9)	40.3 (2.1)	1	4.34	4.67	4.00	4.36					
Phase 5											Storytelling				
1	3	7.67 (1.25)	7.67 (0.94)	39.7 (3.9)	37.3 (3.4)						1	4.04	4.35	3.80	3.96
2	3	7.67 (0.47)	4.67 (1.25)	43.7 (0.9)	44.7 (3.3)						1	3.76	3.55	3.60	4.12
3	4	5.25 (1.09)	3.50 (2.18)	28.8 (7.2)	28.8 (6.5)						1	3.97	4.35	3.80	3.76
4	4	6.75 (1.48)	6.75 (1.64)	44.3 (2.9)	40.8 (2.1)						1	4.09	4.45	3.87	3.96

2.4.2.1 Simple comparison

As demonstrated in Table 2.1, typical patterns of emotion-divergent and emotion-convergent relationships were unrevealed. Therefore, a simple comparison was conducted in each phase as follows:

The synthesis and opportunity-area stage contained two tasks: it began with the formation of themes, which was considered to be a convergent task, followed by the generation of HMWQs,

which was regarded to be a divergent task. The ranking of groups based on the valence level from the most positive to the most negative was: Group 1 (7.00), Group 4 (6.50), Group 2 (6.00), and Group 3 (5.25). This order was congruent to the number of divergent outputs. Group 1 produced the most (6), while Group 3 produced the least (2). However, qualitatively, a contrary relationship was found between this valence order and divergent performance. Group 3 obtained the highest divergent performance score (3.60) while Group 1 earned the lowest score (3.17).

Figure 2.2 represents the plotting of the convergent performance scores of the synthesis (theme) phase and the valence scores, while Figure 2.3 depicts the plotting of the HMWQ divergent scores and the valence scores. The theme scores increased along with the valence scores while the HMWQ scores decreased. The obtained result was contrary to H1a and H1b, which assumed that a positive emotional state would increase divergent performance while a negative affect would decrease convergent performance. Hence, the findings from this phase did not support these hypotheses.

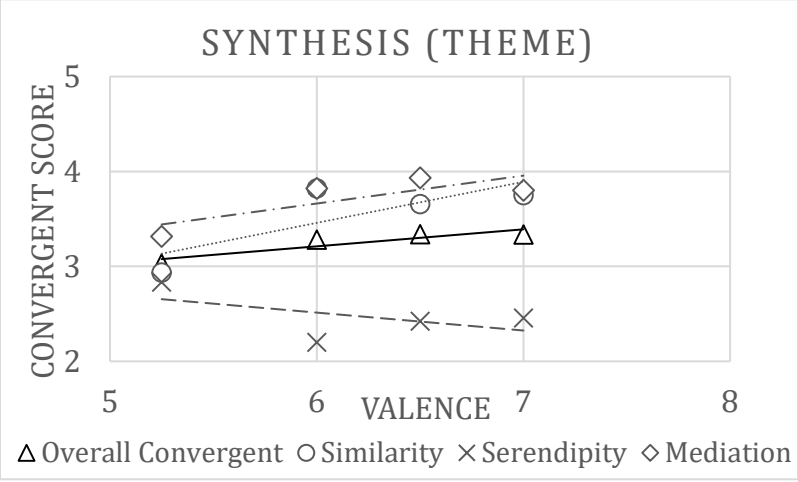

Figure 2.2 Group valence and convergent performance in synthesis phase

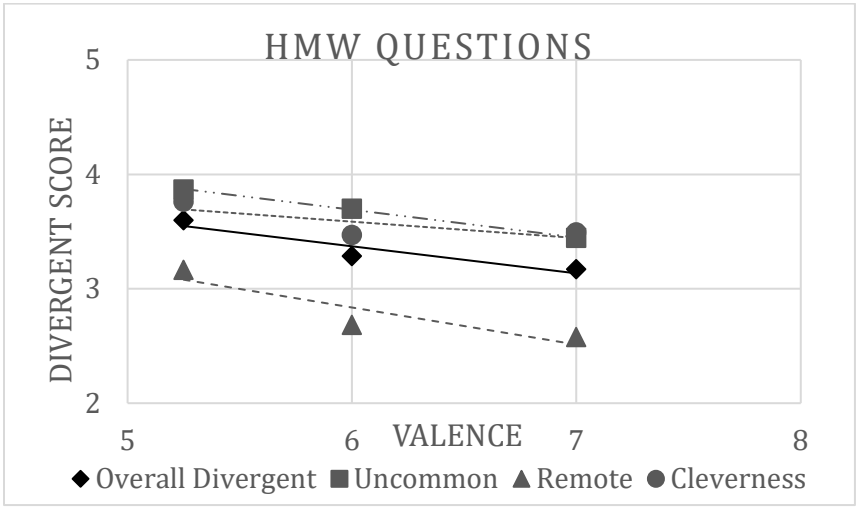

Figure 2.3 Group valence and divergent performance in opportunity-area (HMWQ) phase

The ideation and concept-development stage also comprised two tasks. The phase began with the divergent task of brainstorming and ended with the convergent task of developing a concept. Group 3 scored highest for positive emotion (7.33), followed by Group 4 (7.00), Group 1 (6.67), and Group 2 (6.00). This order was contrary to the concept-development score where Group 2 was the highest (3.90), and Group 3 was the lowest (3.22). Figure 2.4 displays the plot of the concept-development score vs. valence, where the trend line for scores declines with increasing valence. This result supports H1b, which assumed that a rise in valence would result in a decrease in the convergent score.

The arousal order for this second phase ranked Group 4 (7.33) at the top followed by Group 1 (7.00), Group 3 (4.67), and Group 2 (3.67). This order is aligned with the brainstorming scores: Group 4 (3.69) and Group 1 (3.74) surpassed Group 3 (3.33) and Group 2 (3.27). Figure 2.5 shows the plot of the brainstorming score vs. group arousal. The divergent scores are positively related to arousal. This result supports H1c, which assumed increasing arousal would amplify the divergent score.

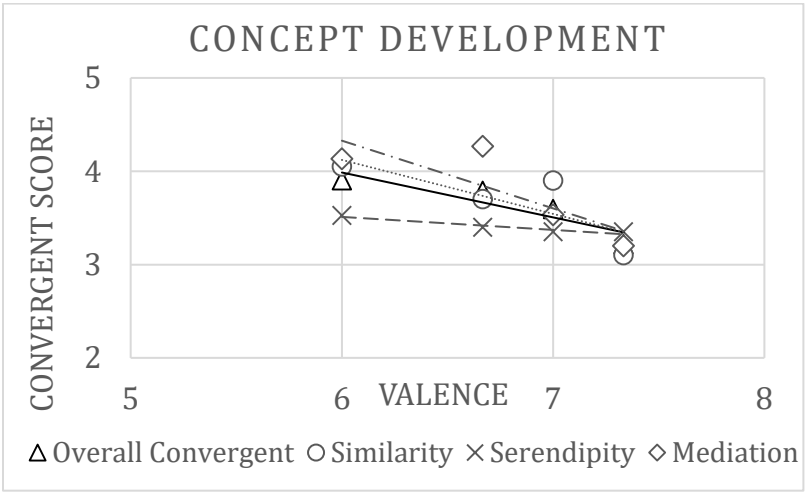

Figure 2.4 Group valence and convergent performance in the concept-development phase

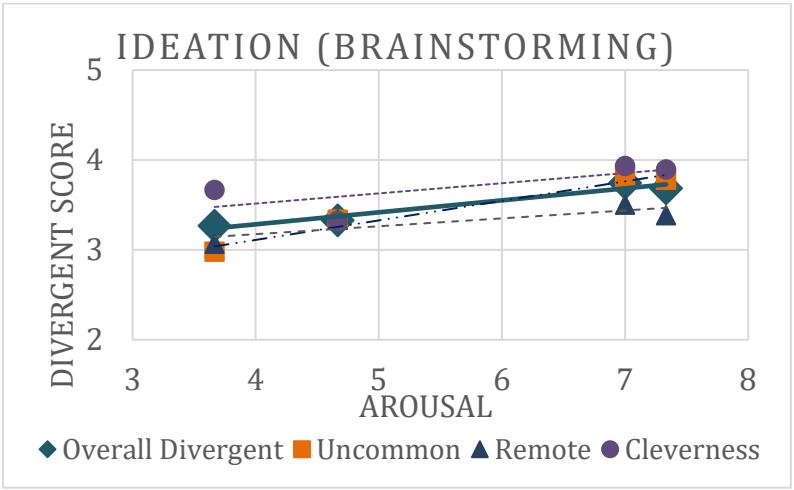

Figure 2.5 Group arousal and divergent performance in the ideation phase

In the prototyping phase, Group 4 obtained the highest overall divergent score (4.04) as well as the highest arousal score (7.00). Group 1, as the second most stimulated group (5.75), earned the second highest overall divergent score (3.94). The overall divergent score was aligned with the uncommonness and remoteness scores. Thus, this result supports H1c. Moreover, Group 1, with the highest valence (8.00), concurrently achieved the highest cleverness score (4.20). The cleverness-valence score relationship confirmed H1a. Figure 2.6 shows the plotting of the

prototyping score vs. group valence. Figure 2.6 illustrates that all divergent subscale scores configure a positive trend line to the valence score.

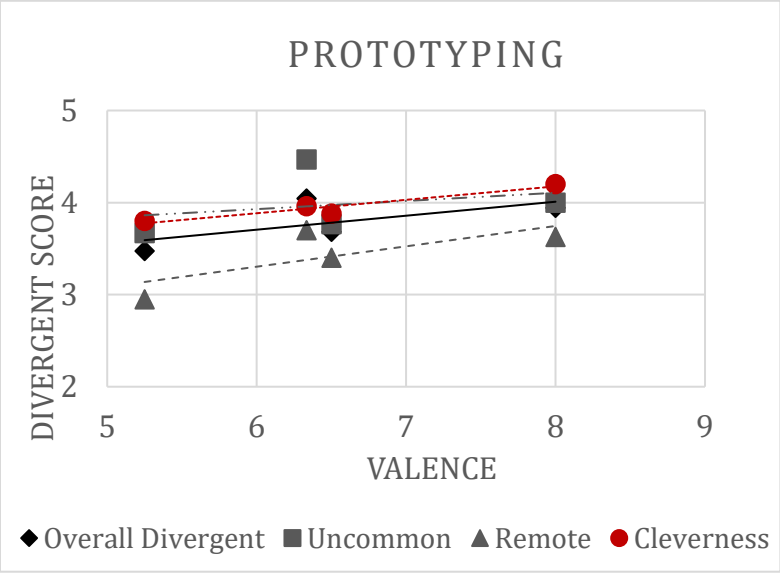

Figure 2.6 Group valence and performance in prototyping phase

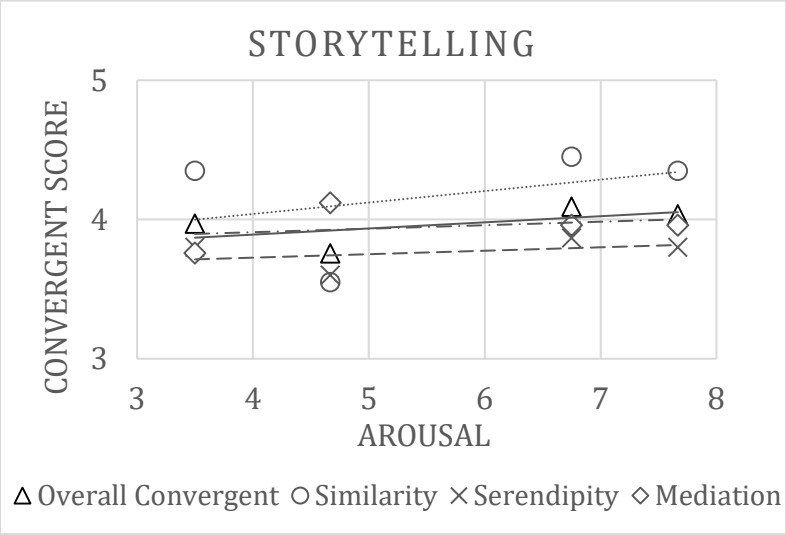

Figure 2.7 Group arousal and convergent performance in storytelling phase

The arousal order for this phase was aligned with the cleverness score in DHP. The highest cleverness score was accorded to Groups 1 and 4, the two most aroused groups. This result partially supported H1c. The last phase, storytelling, did not evidence any support for H1b and H1d. The

data did not reveal that the emotion and convergent scores were negatively linked. Figure 2.7 depicts the plot of the storytelling score against group arousal. Figure 2.7 displays the slightly positive trend of the convergent score in relation to arousal.

Although showing some tendency toward some hypotheses, the results describe above were too crude and inadequate to be concluded. Hence, we run statistical analyses as follows.

2.4.2.2 Correlation test

Individual performance scores were assigned based on group performance scores under the assumption that each member contributed equally to the group. In addition to the mean performance score, the best performance score was also considered for the performance subscales in the subsequent statistical analysis. Skewness statistics indicated that the best mediation violated the normality assumption (−1.013). Even more, this study performed nonparametric correlation analysis taking into consideration the small sample size.

Table 2.2 Spearman's rho correlation coefficients between divergent performance and affective states

Performance Scores	HMWQ (n = 15)		Brainstorming (n = 12)		Prototype (n = 13)		Dark Horse Prototype (n = 13)	
	Valence	Arousal	Valence	Arousal	Valence	Arousal	Valence	Arousal
Mean Uncommon	-.543	-.034	.215	.824**	.415	.594*	-.010	.166
Mean Remote	-.543	-.034	.215	.824**	.415	.594*	-.110	-.094
Mean Cleverness	-.228	.467	-.079	.714**	.626*	.400	.134	.402
Mean Divergent Score	-.543	-.034	.215	.824**	.415	.594*	.148	.470
Best Uncommon	-.101	-.593	.251	.892**	.415	.594*	-.010	.166
Best Remote	-.228	.467	.215	.824**	.351	.531	-.110	-.094
Best Cleverness	.393	.506	-.079	.714**	.618*	.180	.134	.402
Best Divergent Score	-.228	.467	.215	.824**	.415	.594*	.148	.470

$**p < .01$. $*p < .05$. (2-tailed).

Table 2.2 summarizes the Spearman rho correlation results between individual affective scores and divergent performance scores. The positive correlation between valence and cleverness was significant in the prototyping. This result partially supported H1a, which predicted the positive correlation between valence and divergent performance. H1c envisaged a positive correlation

between arousal and divergent scores. Table 2.2 demonstrates that arousal scores were significantly correlated with the divergent score in all subscales of brainstorming. Likewise, arousal significantly correlated with uncommonness and mean remoteness at the prototyping stage. H1c was partially supported.

No evidence was found to support H1b and H1d, which expected negative correlation between the convergent and affect scores. The negative correlation between all convergent subscales and valence was not significant for concept development. On the contrary, significant positive correlation was found between valence and mediation at the storytelling stage. Significant positive correlation also existed between the arousal and the best convergent score for synthesis and storytelling.

2.4.2.3 Mann-Whitney u test

Performance scores between high- and low-scoring groups in terms of affect were compared using a series of Mann-Whitney U tests to examine whether differences in affect scores yielded differences in convergent or divergent performance scores. Individual data were divided into high- and low-scoring groups according to the valence and arousal tallies. The split points were adjusted according to the hypothesis. For H1a, where the valence levels compared were more positive and more negative, the mean of valence in the divergent task was used ($\mu = 6.45$). A similar split point was also used for H1b ($\mu = 6.54$). Thus, data with valence ≥ 7 were compared to those with valence < 7 to test H1a and H1b. Conversely, for H1c, where the arousal levels to be compared were low and moderately high, $\mu - 0.5\sigma = 4.501$ was used as the split point. Thus, data with arousal ≥ 5 were compared to those with arousal < 5 to test H1c. Meanwhile, for H1d, which warranted the comparison of moderately low and high arousal levels, $\mu + 0.5\sigma = 6.573$ was used as the split point. Thus, data with arousal ≥ 7 were compared to those with arousal < 7 to test H1d.

The differences in the divergent scores at different valence levels were first examined. H1a expected positive emotions to result in a higher divergent score than negative emotions. The Mann-Whitney U results showed that mean cleverness (p = .034) and best cleverness (p = .049) significantly differed between participant groups with positive and negative valence in prototyping. Participants with more positive valence were more insightful in the accomplishing of their tasks (average mean = 4.05, average best = 4.14) than those who displayed more negative emotion (average mean = 3.85, average best = 3.90). The effect size for mean cleverness and best cleverness in prototyping were r = .59 and r = .55, respectively, which are large-sized effects. This result partially supported hypothesis 1a.

Meanwhile, other divergent scores at the prototyping stage did not differ between participants with positive and negative valence, and the effect sizes were medium. The divergent score for HMWQ, ideation and DHP did not significantly vary between the two valence levels. In HMWQ, the divergent scores of the positive valence group were lower than those of the negative valence group, while the effect size was medium to small. Participants with positive valence in ideation obtained higher uncommonness and remoteness scores than those with negative valence, but the effect sizes were smaller. Similarly, participants with positive valence in DHP earned higher divergent scores for all subscales than participants with negative valence, while the effect sizes were smaller than typical to medium.

The differences in convergent scores between valence levels were also examined. H1b predicted that participants with more negative valence would obtain better divergent scores than those with more positive valence. All average convergent scores in concept development along with similarity and serendipity in storytelling demonstrated results consistent with H1b. However, the results of the Mann-Whitney U tests evinced no statistically significant differences in all

convergent task scores between the two valence groups. The effect sizes of the convergent score and the valence were, in general, medium except for the mediation score in the storytelling phase. The average mediation score for participants with negative valence was lower than the score of those with positive valence, and the effect size was larger than typical (r = .51). Accordingly, H1b was not supported.

Further, the differences in divergent scores between arousal levels were assessed. H1c forecasted that participants with moderate-high arousal would yield better divergent performances than participants with low arousal.

Table 2.3 Mann-Whitney u test on divergent performance scores between high group and low-group of individual arousal scores

Task	Subscale	Arousal < 5				Arousal ≥5				*P* (2-tailed)	effect size *r*
		n	Mean	SD	Rank	*n*	Mean	SD	Rank		
HMWQ	Mean Uncommon	4	3.743	0.085	6.88	7	3.624	0.230	5.50	.483	0.21
	Mean Remote Mean		2.803	0.245	6.88		2.833	0.315	5.50	.483	0.21
	Cleverness		3.543	0.145	3.88		3.606	0.144	7.21	.089	0.51
	Mean Divergent Score		3.360	0.160	6.88		3.354	0.230	5.50	.483	0.21
	Best Uncommon		4.220	0.100	8.63		4.070	0.000	4.50	.010	0.77
	Best Remote		3.048	0.235	3.88		3.211	0.176	7.21	.089	0.51
	Best Cleverness		3.790	0.220	2.88		4.166	0.043	7.79	.012	0.75
	Best Divergent Score		3.673	0.125	3.88		3.780	0.075	7.21	.089	0.51
Brainstorming	Mean Uncommon	3	3.097	0.202	3.00	9	3.598	0.306	7.67	.046	0.58
	Mean Remote Mean		3.157	0.150	3.00		3.374	0.134	7.67	.046	0.58
	Cleverness		3.553	0.202	4.00		3.752	0.258	7.33	.154	0.41
	Mean Divergent Score		3.270	0.052	3.00		3.573	0.208	7.67	.046	0.58
	Best Uncommon		3.357	0.497	3.00		3.928	0.327	7.67	.035	0.61
	Best Remote Best		3.283	0.144	3.00		3.622	0.243	7.67	.046	0.58
	Cleverness		3.653	0.115	4.00		3.849	0.211	7.33	.154	0.41
	Best Divergent Score		3.357	0.098	3.00		3.671	0.208	7.67	.046	0.58
Prototype	Mean Uncommon	2	3.885	0.163	7.00	11	3.987	0.339	7.00	1.000	0.00
	Mean Remote Mean		3.515	0.163	7.00		3.381	0.351	7.00	1.000	0.00
	Cleverness		4.040	0.226	8.50		3.960	0.168	6.73	.539	0.17
	Mean Divergent Score		3.810	0.184	7.00		3.773	0.260	7.00	1.000	0.00
	Best Uncommon		4.035	0.050	7.00		4.027	0.332	7.00	1.000	0.00
	Best Remote Best		3.650	0.000	7.50		3.409	0.365	6.91	.832	0.06
	Cleverness		4.220	0.141	10.00		4.015	0.220	6.45	.220	0.34
	Best Divergent Score		3.960	0.057	7.00		3.811	0.272	7.00	1.000	0.00
DHP	Uncommon	8	4.373	0.297	6.63	5	4.482	0.257	7.60	.651	0.13
	Remote		3.838	0.322	6.63		4.040	0.055	7.60	.651	0.13
	Cleverness		4.180	0.117	5.13		4.360	0.000	10.00	.016	0.67
	Divergent Score		4.130	0.202	5.50		4.292	0.066	9.40	.070	0.50

Table 2.3 summarizes the results of the Mann-Whitney U tests on the divergent performance scores between individual high-group and low-group arousal scores. Table 2.3

outlines supporting results in the best remoteness and cleverness scores with regard to HMWQ, the overall divergent scores pertaining to brainstorming, and the overall divergent scores of DHP. In the interim, the results of prototyping did not yield supporting evidence. The Mann- Whitney U test confirmed that the two groups were significantly different in the highest cleverness score on HMWQ, in uncommonness and remoteness in brainstorming, and in cleverness in DHP. The effect size for those subscales ranged between larger than typical to much larger than the norm. On the contrary, the Mann-Whitney U Test confirmed the opposite result that participants with negative valence were significantly higher in the uncommonness score in HMWQ than those with positive valence and the effect size was much larger than typical. Hence, H1c was partially supported.

Finally, the difference in convergent scores across arousal levels was examined. H1d assumed that participants with moderate-low arousal would demonstrate better divergent performance than those with high arousal. The Mann-Whitney U Test confirmed that the two groups were not significantly different, thus H1d was not supported.

2.4.3 Emotion and leadership correlation

The skewness of the ROL data was lower than −1. Considering this normality violation and the small number of samples, a non-parametric correlation analysis was applied toward affect variables and leadership behavior perception.

The correlation was evaluated both at the group and the individual levels. Leadership behavior and affect scores were not significantly correlated at the group level. At individual level, however, the perception of ROL and valence were significantly correlated ($r_s = .394$, $p = .01$). This result supported H2a which envisaged that ROL and valence would be positively correlated.

A Mann-Whitney comparison test was conducted to investigate whether valence and arousal were different between groups with high ROL and high TOL. A group with higher ROL

score exhibited higher arousal than a group with higher TOL (p = .049). The effect size for group arousal was r = .45, a medium-size effect. This outcome supports H2b.

2.4.4 Leadership and performance correlation

Further investigation was conducted to reveal the connections between emergent leadership and group affect in different types of creative performance. Additionally, the relationships between emergent leadership and each creative performance were examined.

In overall divergent tasks, ROL significantly correlated with valence (r_s = .42, p < .01). Meanwhile, TOL evinced a significant negative correlation with arousal in HMWQ (r_s = −.63, p < .05). ROL was not significantly correlated with divergent scores except for the best remoteness in prototyping (r_s = .55, p < .05). TOL showed a significantly negative correlation with the best cleverness scores in HMWQ (r_s = −.63, p < .05) and for remoteness in DHP (r_s = −.88, p < .01). Yet, TOL was positively correlated with best uncommonness in HMWQ (r_s = .61, p < .05). Leadership behavior was significantly correlated with some affect and convergent scores for convergent tasks. No significant correlation was found for ROL with either valence or arousal, while TOL was significantly correlated with valence in storytelling (r_s = .65, p < .05). TOL correlated positively with several convergent scores, specifically mean mediation in overall convergent tasks (r_s = .35, p < .05), best serendipity in overall convergent tasks (r_s = .34, p < .05), best similarity in theme (r_s = .57, p < .05), similarity in concept development (r_s = .78, p < .01), and mediation in storytelling (r_s = .80, p < .01).

ROL correlated positively with mean mediation in overall convergent tasks (r_s = .42, p < .01), storytelling (r_s = .80, p < .01), and best similarity in theme (r_s = .52, p < .05). However, a negative correlation was found between mean serendipity and emergent leader in theme: TOL (r_s = −.57, p < .05) and ROL (r_s = −.52, p < .05).

2.5 Discussion

2.5.1 Effect of emotion on creative design performance

This study investigated the varied affective states experienced in the creative design process. The participants perceived a neutral to positive valence and low to high arousal. The affect states differed among groups and fluctuated vigorously in the course of the discrete phases.

2.5.1.1 Divergent performance subscales

The relationship between affect and divergent performances differed across the assigned tasks. A conflicting pattern of uncommon and cleverness was found in three divergent phases. The contrary results were found in the association of the scores with arousal in HMWQ (see Tables 2.2 and 2.3), valence in brainstorming (see Figure 2.5), and both valence and arousal in prototyping (see Table 2.2). These results asserted the independence of the subscales. A response could be high in one subscale but low in another (Silvia et al., 2008). This difference affected the generality of the relations between affect and divergent performance. However, Silvia et.al (2008) have asserted that divergent thinking tasks capture the different aspects and dynamics of ideation. Thus, the differences found in the relation between performance and affect do not indicate invalidity.

2.5.1.2 Valence and divergent performance

Relationships between valence and divergent performance were found to be dissimilar across tasks. Positive associations between valence and divergent performance scores were confirmed in the remoteness and cleverness subscales in brainstorming and in all subscales in prototyping but were uncommon in DHP. However, only the cleverness subscale in prototyping was shown to be statistically significant. In opposition to previous research reporting that positive emotion would facilitate divergent thinking at the individual level (e.g., Yamada & Nagai, 2015),

the results obtained in the current study suggest that the implications derived from previous studies may not be directly applicable at the group level.

Tsai et al. (2011) proved that the weak relationship between valence and group creative performance might occur because of another factor that, when combined with a certain level of valence, may inhibit creative performance. Their study demonstrated that a group with both high-team trust and high positive group emotion produced fewer creative ideas than a group with either team trust or positive group emotion. Similarly, Collins et al. (2013) have mentioned that groups with a highly positive affective tone and a significant amount of trust among group members were less likely to express diverse opinions. Positive emotion stemming from a sense of reliance on other members to complete the group task might actually hinder creative group performance, especially in the divergent aspects. A further exploration of the trust factor and its effect on different kinds of divergent tasks would be interesting.

2.5.1.3 Arousal and divergent performance

Groups with higher arousal performed better in most of the divergent tasks. The arousal correlated positively with divergent scores in brainstorming and prototyping. The groups that evinced higher arousal levels scored better in best remoteness and cleverness subscales of HMWQ, in the overall divergent subscale of brainstorming, and in the cleverness aspect of DHP. These results reveal that arousal was more strongly related to divergent group performance than valence. The findings support the notion that arousal is more critical than valence in influencing heuristic cognition (Imbir, 2016), while heuristic cognition concurs with divergent thinking (Knörzer et al., 2016).

Group work mandates contributions from members in the development of ideas, or the "cross fertilization of ideas" according to the nomenclature devised by Tsai et al. (2011). The

perception of urgency, which is reflected by arousal (Zadra & Clore, 2011), may support the contributory actions of members to the group's work. Sosnowska, Hofmans, and de Fruyt (2017) have shown that people possess high energy, passion, and mental endurance to achieve their work when they are in a state of high arousal. Consequently, the maintenance of positive group emotion is not as important as the preservation of group arousal at the moderate to high level during the accomplishment of divergent tasks. A challenging task combined with the expression of different opinions in a group may lead to a negative state of emotion yet increase arousal, which would be beneficial for the group's divergent performance.

The results obtained by this study are aligned with the findings of De Dreu et al. (2008) with regard to overall affect states related to divergent performance. De Dreu et al. (2008) revealed that people in a happy and angry state performed well in divergent tasks. Both emotions indicate an activating state. People are likely to be more persistent in a state of anger than while exhibiting any other emotion such as happiness, relaxation, or sadness (De Dreu et.al., 2008). The current research confirmed that novel ideas may be obtained not just through the ability to think in a broad manner but also through strenuous and earnest effort.

2.5.1.4 Emotion and convergent performance

This study did not find any significant relationship between affect variables and convergent tasks. Although concept development revealed a higher convergent score in the negative emotion group, the relationship was not statistically significant. Similarly, no significant association was revealed between arousal and convergent performance. In congruence with previous research, convergent tasks were found to be more associated with cognitive reasoning (e.g., De Young et al., 2008). This outcome does not imply that emotions do not influence convergent performance. For example, confusion (negative-aroused) is beneficial for focused attention, deep thinking, and

judgment (D'Mello, Lehman, Pekrun, & Graesser, 2014). However, further research must deliberate how affects can be categorized to elucidate the general.

2.5.2 Effect of emergent leadership on group creative work

Participants perceived more ROL than TOL in this study. The relationship between emergent leadership and group emotion and the manner in which this dynamic affects group creative work are discussed below:

2.5.2.1 Emergent leadership and group emotion

For most of the design thinking task, the participants faced an unknown, ill-defined, and vague situation, also called a low control situation by Fiedler and Chemers (1984). In this uncertain condition, the emergence of ROL would be beneficial in maintaining a pleasant atmosphere. The overall data of this study evidenced the domination of positive emotion and ROL. This investigation revealed that the emergence of ROL is positively associated with group affect. The perception of ROL by group members formed a positive correlation with their valence, particularly in divergent tasks.

Group members who perceived more ROL were more aroused than those who sensed more TOL. Likewise, the existence of TOL tended to decrease arousal levels in HMWQ. These findings were consistent with the researchers' initial idea that ROL might lead to more positive and higher group emotion than TOL.

However, the empirical data demonstrated a significant positive correlation of TOL with valence in storytelling. This finding may indicate that storytelling represents a higher control condition. According to Fiedler and Chemers (1984), in this situation, the emergent TOL can clearly envision how to manage the task. Thus, the leader tends to spend more time socializing with other group members and showing consideration for their feelings. This action might increase

the positive emotions of members. After facing conditions of much uncertainty in previous phases, the students gained a better understanding and conducted the storytelling more vividly. Afterward, they produced their proposal for the solution to their challenge. In a way, this result partially supported Pescosolido's (2005) notion that emergent group leaders manage group emotion.

2.5.2.2 Emergent leadership and group performance

This study did not reveal any strong benefit of emergent leadership for the performance of tasks that require divergent thinking. ROL correlated positively only with the best remoteness score in prototype, while TOL correlated negatively with the best cleverness score of HMWQ and the remoteness score of DHP. It was expected that TOL would hinder divergent performance. TOL behavior such as obtaining concrete intention, evaluating prior action, or assuming existent situations (Behrendt, Matz, & Göritz, 2017) may block the flow of ideas. Meanwhile, ROL people tend to focus indirectly on task completion instead of group engagement. Such leaders foster coordination and promote cooperation (Behrendt et al., 2017), which is not required to generate ideas.

However, the current research showed that an emergent leader partially supports convergent tasks. TOL supported the best similarity score in theme and concept development, best serendipity score in the overall convergent task, and mediation in storytelling. ROL supported the best similarity score in theme and the mediation score in storytelling. However, the reliability of the mediation scale was low and thus, the role of the emergent leaders in mediation needs further careful investigation in the future.

In general, this study implied that even though emergent leadership did not support creative group work through the managing of emotions, it may directly support convergent tasks. Associating a convergent task with a high-task structure appears reasonable. Fiedler and Chemers

(1984) have also noted that TOL performs well in such situations. This investigation only found partial evidence of the role of emergent leadership in the creative task, perhaps because creative assignments elicit different behaviors. Hence, further research is required for a more profound understanding of the functioning of emergent leaders in creative group work.

2.5.3 Limitations and future research directions

This study was conducted in a natural setting that imposed several limitations. The investigation depended on a small number of groups and participants, and on a limited range of valence conditions. No negative valence conditions such as anxiety or depression existed. The tendency of positive emotions perceived in design thinking tasks may be credited to the work process behavior. Divergent thinking, which was dominant in the design thinking task, may have led to a more positive mood (Akbari, Chermahini, & Hommel, 2012). However, further studies are necessary to prove this notion.

In addition, this study was unable to determine the causality of the affect, leadership, and creative performance relationships. Experimental studies that involve both divergent and convergent tasks and that take into account the task order would be interesting and would yield deeper insights.

2.6 Chapter Summary

The present study confirmed that emotion, especially the state of arousal, was positively related to the performance of divergent tasks. The results implied that medium-high arousal was the optimal state in which to accomplish divergent tasks in a group. A comfortable atmosphere may not be a prerequisite for the devising of fabulous, novel ideas if the group members are

actively engaged and if they strive to share their thoughts. This insight may be used by teachers or managers to maintain a creative atmosphere in the classroom or the workplace.

Brown's (2009) notion that leaders are not necessary for a divergent task was confirmed by this study. It may thus be asserted that the performance of divergent tasks relies on the egalitarian status of members within a group. However, this study also revealed the need for leadership in creative group work. Although the present investigation did not demonstrate a significant relationship between the emergent leader's function of managing group emotion and group performance, the emergence of leadership nevertheless facilitates the association of ideas in a creative group task. Design managers might control the involvement of TOL in their group work and may thus be able to increase the group's creative performance.

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Chapter 3. Change in Affective Experience in Convergent and Divergent Creative Group Works

3.1 Introduction

The creative process produces novel and useful ideas in relationship to affective experience (Amabile, Barsade, Mueller, &. Staw, 2005). Individuals use divergent thinking to generate ideas, and convergent thinking to select the most promising ideas and plans to perform a task successfully (Lewis & Lovatt, 2013). How creativity through divergent and convergent thinking is influenced by affective experience has been explored extensively, and the concept that positive affect supports divergent thinking and creativity has been widely accepted (Amabile et al., 2005; Politis & Houtz, 2015). However, study in chapter 2 revealed inconsistent results and showed tendencies that the design thinking process inflicted positive affects instead.

Some studies have investigated the converse of this relationship, looking at whether the creative thinking process itself influences affective experience (Amabile et al., 2005). Akbari, Chermahini, and Hommel (2012) have revealed that divergent thinking influences the valence of a task positively, and convergent thinking negatively influences valence. Moreover, a divergent task increases positive affect regardless of the performance level (Lewis & Lovatt, 2013).

Insight about how the thinking process influences affective experience would help individuals and organizations determine how to maintain a creative atmosphere that facilitates the well-being of individuals within work groups. However, most research conducted in a laboratory setting has used only single-set individual tasks. In fact, a creative project possessed complexity, which is evoked by, such as, sequential tasks and group work. Since creative tasks performed in a group might expand the affective experience, and creative task performance often involves interspersing divergent and convergent thinking tasks in a specific order (Jaarsveld & Lachmann,

2017) the combination and order of the divergent and convergent tasks that go into a creative project may evoke positive or negative affect according to the way they intertwine. Likewise, this study is aimed at investigating how the order of divergent and convergent tasks as part of the creative process influences changes in the affective experiences of workgroup participants.

3.2 Hypotheses

The authors of the study assumed that affective experience would be influenced by the type of creative task and the order in which the tasks are performed. The group-related factors will be discussed as well.

3.2.1 Influence of types of creative task on affective experiences

Amabile et al. (2005) proposed ideas on how creativity influences affect. Because creativity is a work event, it could evoke affect in a way similar to other work events. For instance, a person might feel excited when discovering a unique idea and this would elevate a positive effect. Conversely, they might become overwhelmed by trying to decide on one of several proposals for implementing their idea, which may lead to having a negative affective state.

Divergent thinking is characterized by the ability to be flexible (Lewis & Lovatt, 2013), broad (Ashton-James & Chartrand, 2009), and holistic (DeYoung, Flanders, & Peterson, 2008) in one's thinking. It deals with ambiguity, and thus it draws on intuition and heuristic processing (DeYoung et al., 2008; Knörzer, Brünken, & Park, 2016). Likewise, a positive affective state, which indicates a high level of pleasure/valence shows people's interest in a task (Knörzer, et al., 2016; Newton, 2013). It helps to generate new ideas by promoting flexible thinking (Yamada & Nagai, 2015). Accordingly, divergent thinking is aligned with the positive affect. Conversely, characteristics of convergent thinking are logical thinking, analytical, performing on a well-

defined problem, and facilitating collaboration (Lewis & Lovatt, 2013; Ashton-James & Chartrand, 2009). This type of thinking is associated with negative affect and a narrowing attention focus (Knörzer et al., 2016; Newton, 2013).

Although the positive affect generally supports divergent thinking and the negative affect promotes convergent thinking, Akbari et al. (2012) noted that these patterns also work inversely. They argued that the human cognitive system has a self-optimizing system to handle tasks. Keeping a focused control state arises negative affect while defocusing control state is followed by positive affect. We assume that this control ability occurs in the interlace of divergent–convergent thinking as well, and thus will change affect level accordingly. Hence, we derive the following hypotheses:

H1a. Divergent tasks change valence to positive while convergent tasks change valence to negative.

Furthermore, affective experience has another element related to urgency, namely, arousal (Zadra, & Clore, 2011). Chermahini and Hommel (2012) did not find any evidence to support that the different task types influence arousal. However, the concept of valence and thinking type mentioned earlier are mostly related to an individual task. Meanwhile, group work might behave differently in terms of the relationship between affect and cognitive processes. Arousal helps people to express their ideas especially when they are working as a team (Tsai, Chi, Grandey, & Fung, 2011). Imbir (2016) argued that arousal influences the heuristic cognition, which is associated with divergent thinking. Accordingly, we derived the following hypotheses:

H1b. Divergent tasks increase arousal while convergent tasks decrease arousal.

3.2.2 Influences of task order on affective experiences

The changes in affects would not only be influenced by the types of tasks but also by the predecessor process. A former task might influence the control for conducting a later task. The earlier task may become a reference to change behavior to gain better performance (Håkonsson, Eskildsen, Argote, Mønster, Burton, & Obel, 2015). In other conditions, people may continue the former action they had known well regardless of the effect of the behavior on the further task (Albarracín, & Wyer Jr, 2000). Consequently, an affective state in the second process might be attached by the first process. Assuming that the first task was exempted from another cognitive task, we propose the following hypothesis:

H2. Affect change after the first task is greater than affect change after the second task.

3.3 Method

3.3.1 Participants

Twenty-two undergraduate and graduate students, (7 females, 15 males) enrolled in a design project-based course, participated as subjects. They had an average age of 24.23 years (*SD* = 2.91, range 21–35). The majority of the subjects identified themselves as Japanese (45%). Others were German (23%), Non-Japanese Asian (23%), and African (9%). Twenty of the subjects were master's students, and two others were an exchange student and a research student. Sixty-eight percent of the subjects belonged to the Industrial Engineering department. All students were assigned to one of four groups by the researchers based on their backgrounds and gender to create similar groups.

3.3.2 Research design (class context/outline)

Again, this research was conducted on the design thinking course, the process of which has been described in Chapter 2. Some adjustments that did not interfere with the learning process were made to meet the research objectives. The course used intertwined divergent and convergent tasks as processes to create an innovative solution to a real-world problem. There were four classes that had a 2 x 4 combination of divergent and convergent tasks selected for the study. This composition allowed the researchers to conduct comparative studies between the type of task (divergent and convergent) as well as the task order (first and second). HMW question task done outside the classroom was not involved in this study, while storytelling was excluded because the class only comprised one type of task. Figure 3.1 illustrates the task combinations in each class.

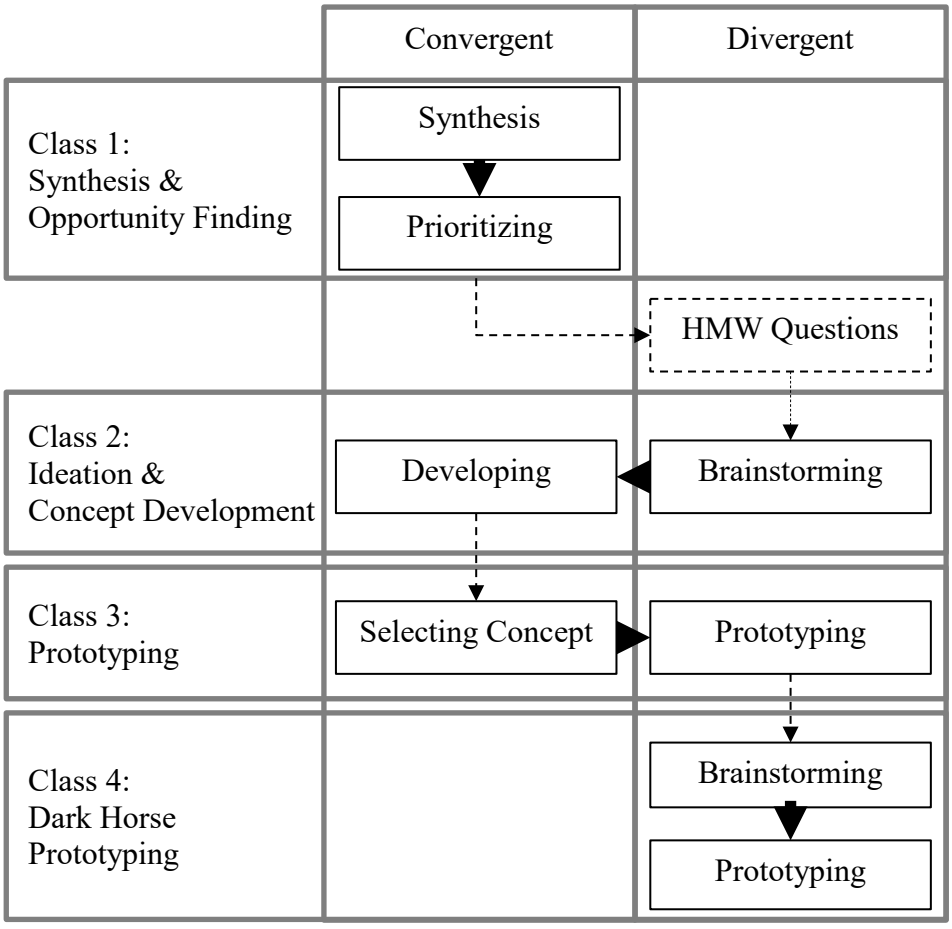

Figure 3.1 Flow of creative tasks in design thinking

The four classes conducted creative tasks with fixed group members. Each of the class meetings was preceded by a lecture class in a previous week to explain related concepts and practices. Between a class and the following, there was a time lag of two to three weeks.

In Class 1, students performed a synthesis task and a prioritizing theme task consecutively. In the synthesis task, students produced themes by combining similar information from the previous week's class. This task was followed by the prioritizing theme task in which students reviewed the themes they had produced in the previous task, and then they selected two or three of the most exciting themes to be prioritized. As the combining, organizing, and choosing in these tasks were convergent processes, these two tasks, for this class, were categorized as convergent.

Class 2 started with a brainstorming task. In this task, students elaborated ideas on the themes they had chosen in the previous class. Thus, this task was considered a divergent task. The second task of Class 2 was developing a concept starting with the three to five most interesting ideas from their brainstorming process. Each idea was described in a more detailed concept including the idea's definition, features, unique points, and its potential benefits. This process was demarcated as the convergent task.

Class 3 used the combination of a convergent task followed by a divergent task. It started with selecting one concept among three to five concepts students made in the previous class. Then it proceeded with creating a prototype to visualize the selected concept. Students were encouraged to develop the prototype quickly and spontaneously. This prototyping task was considered to be a divergent task.

Class 4 was assigned to change the concepts discussed in the previous class. Students were asked to create a new and fresh idea to produce an innovative solution. This class started with brainstorming, followed by dark-horse prototyping. The two tasks were regarded as divergent tasks.

3.3.3 Measurement

Affective states of the subjects in terms of valence and arousal were measured with the Self- Assessment Manikin scale (Bradley & Lang, 1994). The set of questionnaires consisted of two 9-point scales (valence:1 = negative, 9 = positive; arousal: 1 = low, 9 = high) using five pictures to represent level of valence and arousal.

3.3.4 Procedure

Subjects were asked to fill in the questionnaire three times in each of the four classes, every two or three weeks. In order to identify the subject while keeping the responses anonymous, participants were asked to write a unique trace code on the cover page of the questionnaire every time it was used throughout the study.

Subjects were asked to respond to the questionnaire just before the first task to get the initial affect data (Time 1). Then, students were instructed about their first task. It took less than 5 minutes to initiate the class and collect the data before the students moved on to the first task.

After performing the first task which took 30 to 45 minutes, the students were asked to return to their individual seats and fill out the second questionnaire to measure their affective state (Time 2). Then they listened to instructions about the second task. The break time for filling the questionnaire was less than 5 minutes. After students performed the second task which took about 30 minutes, they were again asked to return to their seat and complete the last questionnaire (Time 3) for 5 minutes.

3.3.5 Data analysis

The comparison analysis using a series of paired t-tests identified the effect of task types and order on the subjects' affective experience. The affect level and change were used to determine the impact of task types. The order of affect was analyzed by using the affective distance data.

3.4 Results

3.4.1 Descriptive statistics of affect scores

Table 3.1 summarizes the means and standard deviations of valence and arousal levels at three measurement times for each of the four classes. In Time 1, the affective levels were near neutral in almost all groups. Class 1 possessed the highest average valence score (M = 6.05) and Class 3 had the lowest (M = 5.14). The highest average arousal score belonged to Class 4 (M = 4.91), and the lowest was for Class 3 (M = 4.00). The average valence and arousal scores were increasing in the second measurement time except for the average valence of Class 1 (M = 5.77) Both scores coincided with a convergent task. The highest average valence and arousal scores for Time 2 were in Class 2 (M = 6.05) and Class 4 (M = 6.00), respectively. Both scores coincided with a divergent task. The lowest average affective score for Time 2 was in Class 3 (valence = 5.33; arousal = 4.70) which coincided with a convergent task. In Time 3, the average affect scores increased in Class 1 (valence = 5.50; arousal = 4.95) where both tasks were convergent. Figure 3.2 and Figure 3.3 illustrate the average valence and arousal levels, respectively.

Table 3.1 Comparison of affective level in time 1, time 2, and time 3 – paired sample t-test

Class	Affect State	*n*	Time 1		Time 2		Time 3		Comparison Time 2 vs. 1		Comparison Time 3 vs. 2	
			M	***SD***	***M***	***SD***	***M***	***SD***	***t***	***p***	***t***	***p***
Class 1	Valence	22	6.05	1.40	5.77	1.60	5.50	1.87	-0.709	0.486	-1.142	0.266
	Arousal	22	4.77	1.69	5.36	1.79	4.95	2.10	1.846	0.079	-2.001	0.059
Class 2	Valence	21	5.57	1.54	6.05	1.47	6.43	1.54	1.173	0.255	1.504	0.148
	Arousal	21	4.14	1.65	5.38	1.83	5.76	1.64	2.994**	0.007	1.321	0.202
Class 3	Valence	21	5.14	1.42	5.33	1.49	6.38	1.32	0.698	0.493	4.481**	0.000
	Arousal	20	3.90	1.25	4.70	1.69	6.10	1.68	3.238**	0.004	4.765**	0.000
Class 4	Valence	22	5.73	1.24	5.95	1.43	6.27	1.61	0.738	0.469	1.322	0.200
	Arousal	22	4.91	2.14	6.00	1.54	6.36	1.56	2.982**	0.007	1.789	0.088

*$p < .05$, **$p < .01$. (2-tailed)

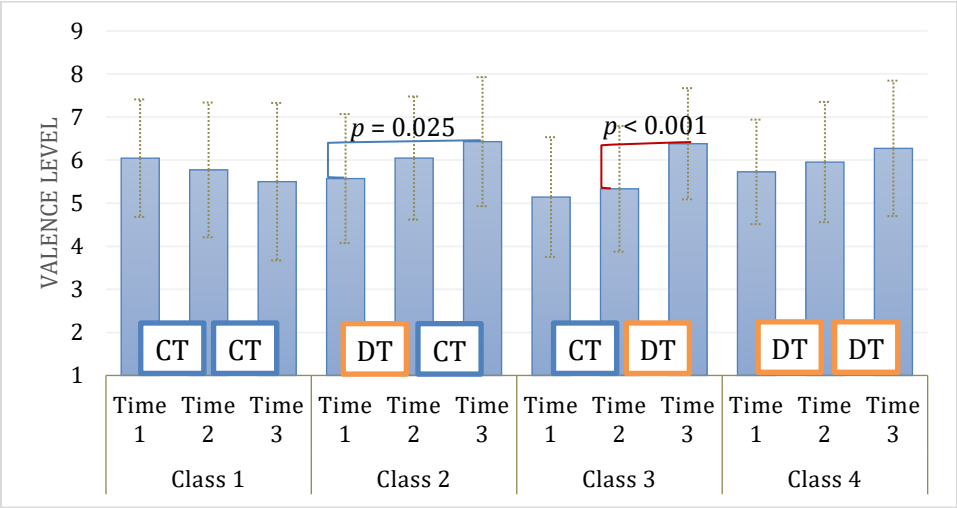

Figure 3.2 Valence score in creative group activities. DT = divergent task; CT = convergent task.

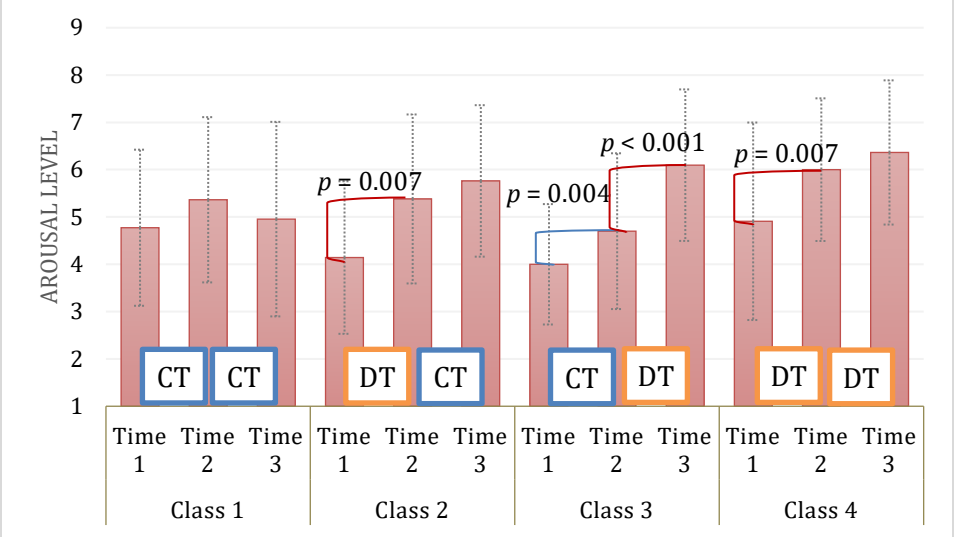

Figure 3.3 Arousal score in creative group activities. DT = divergent task; CT = convergent task.

Figure 3.4 shows the plots of average scores of valence and arousal. It illustrates the changes in affect over three measurement times in each class. Generally, after conducting the convergent process (i.e., Times 2 and 3 in Class 1, Time 2 in Class 3), affects remained around the neutral level. However, the subjects' affects shifted to more positive after the divergent tasks (e.g.,

Time 2 in Class 2). After performing the two consecutive convergent tasks in Class 1, the subjects' affect scores became more negative. The other three class meetings showed similar patterns.

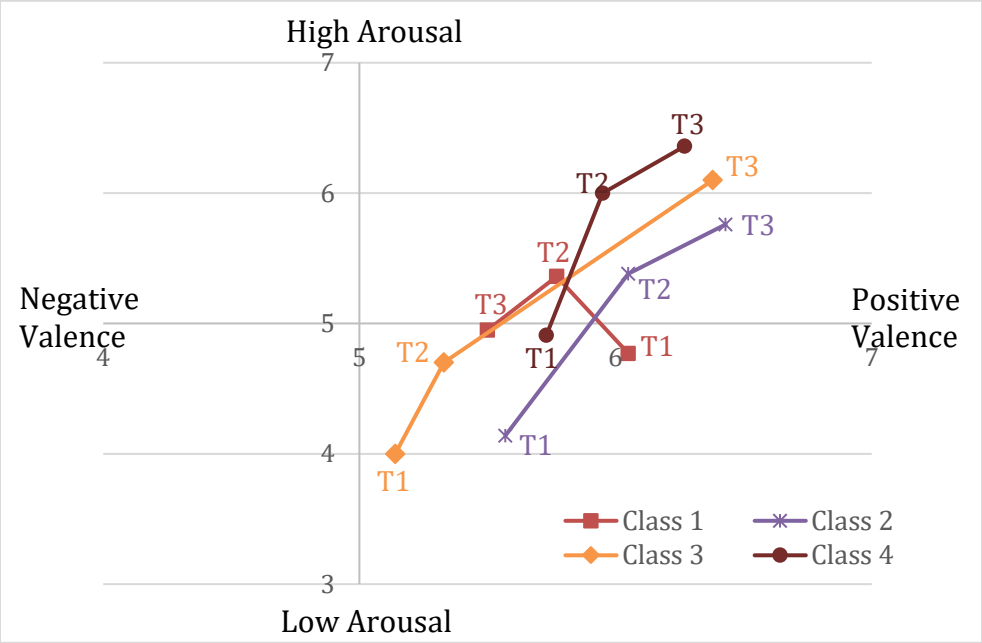

Figure 3.4 Affect movement in valence-arousal plane

3.4.2 Affective level

Hypothesis 1 assumed that a divergent task would change the valence to positive and increase arousal levels while convergent works contrarily. Accordingly, the authors predicted that valence and arousal levels would be higher after a divergent task than after a convergent task. The affect levels for Time 2 and Time 3 were compared separately to avoid order bias.

A series of paired t-test for the second measurement time did not show any significant differences in affect levels between the divergent and convergent tasks except in the arousal level of Class 3 and Class 4. The arousal level after performing the convergent task in Class 3 ($M = 4.70$, $SD = 1.69$) was significantly lower than after performing the divergent task in Class 4($M = 5.90$, $SD = 1.59$; $t\ (19) = -2.854$, $p < 0.01$). Hence, this result supported H1b partially.

For the third measurement time, the paired t-test showed some significant differences in the affect levels between the convergent and divergent tasks. The valence level on the convergent task in Class 1 (M = 5.38, SD = 1.83) was significantly lower than the valence on the divergent task in Class 3 (M = 6.38, SD = 1.32; t (20) = 2.603, $p < 0.05$) and Class 4 (M = 6.27, SD = 1.61; t (21) = -2.112, $p < 0.05$). The arousal level on the convergent task in Class 1 (M = 4.81, SD = 2.04) was significantly lower than the arousal level on the divergent task in Class 3 (M = 6.10, SD = 1.64; t (20) = -2.63, $p < 0.05$) as well as in Class 4 (M = 6.36, SD = 1.56; t (21) = -2.87, $p < 0.01$). Likewise, the arousal level on the convergent task in Class 2 (M = 5.76, SD = 1.64) was lower than on the divergent task in class 4 (M = 6.38, SD = 1.60; t (20) = -2.444, $p < 0.05$). Thus, these results supported H1a and H1b partially.

3.4.3 Affective level change

The affect level change was defined as the difference in the subjects' affective levels before and after a task, specifically between the first and second measurement for the first task, and between the second and third measurements for the second task. Referring to hypothesis 1, the authors assumed that the valence and arousal levels would change positively in the divergent task so that the level after the task would be higher than before the task. Conversely, the valence and arousal levels would change negatively in the convergent task. Thus, the levels after the task would be lower than before the task.

Table 3.1 summarizes the results of comparisons of the valence scores and arousal scores between measurements Time 2 and Time 1, as well as between measurements Time 3 and Time 2. As shown in Figure 3.2, valence scores increased in all divergent tasks. A series of paired t-tests showed a significant change in valence in the divergent task in Class 3. In Class 3, the valence level after the divergent task (M = 6.38, SD = 1.32) was higher than before the divergent task (M

= 5.33, *SD* = 1.49; *t* (20) = 4.48, $p < 0.001$). Even though Class 2 contained the convergent task in the second process, the valence level after the second task (*M* = 6.43, *SD* = 1.54) was significantly higher than before the first task (*M* = 5.57, *SD* = 1.54; *t* (20) = 2.42, $p < 0.05$). The decrease of valence was observed only in the convergent–convergent combinations in the first class; however, the change was not statistically significant. Hence, these results partially supported H1a.

Paired t-tests, as shown in Figure 3.3, revealed that arousal levels increased significantly after all divergent tasks except for prototyping in Class 4. In Class 2, the arousal level after the divergent task (*M* = 5.38, *SD* = 1.83) was higher than before the divergent task (*M* = 4.14, *SD* = 1.65; *t* (20) = 2.99, $p < 0.01$). In Class 3, the arousal level after the divergent task (*M* = 6.10, *SD* = 1.68) was higher than before the divergent task (*M* = 4.70, *SD* = 1.69; *t* (19) = 4.77, $p < 0.001$). In Class 4, where two divergent tasks were performed in sequence, the arousal level in Time 2 (*M* = 6.00, *SD* = 1.54) was higher than Time 1 (*M* = 4.91, *SD* = 2.14; *t* (21) = 2.982, $p < 0.01$). Meanwhile, even though not significantly higher than the arousal level in Time 2, the arousal level in Time 3 (*M* = 6.36, *SD* = 1.56) was significantly higher than in Time 1 (*t* (21) = 3.016, $p < 0.01$). Conversely, the decrease of the arousal level appeared in the second process of the convergent task in Class 1 was not statistically significant. Even Class 2 and 3 showed an increase in arousal level after the convergent task. Accordingly, H1b was partially supported.

3.4.4 Affect distance change

In order to quantify the extent of the change in the affective experiences, the concept of Euclidean distance was introduced. Change in individual affect was measured across a distance on the valence–arousal plane. As an example, Figure 3.5 depicts the scores for a student on the valence–arousal plane as Time 1 (valence = 7; arousal = 7), Time 2 (valence = 6; arousal = 5), and Time 3 (valence = 4; arousal = 3). The first Euclidean distance between Time 1 and Time 2 is

calculated as 2.24 and the second distance between Time 3 and Time 2 is 2.83. The individual distance scores were averaged and compared as shown in Table 3.2.

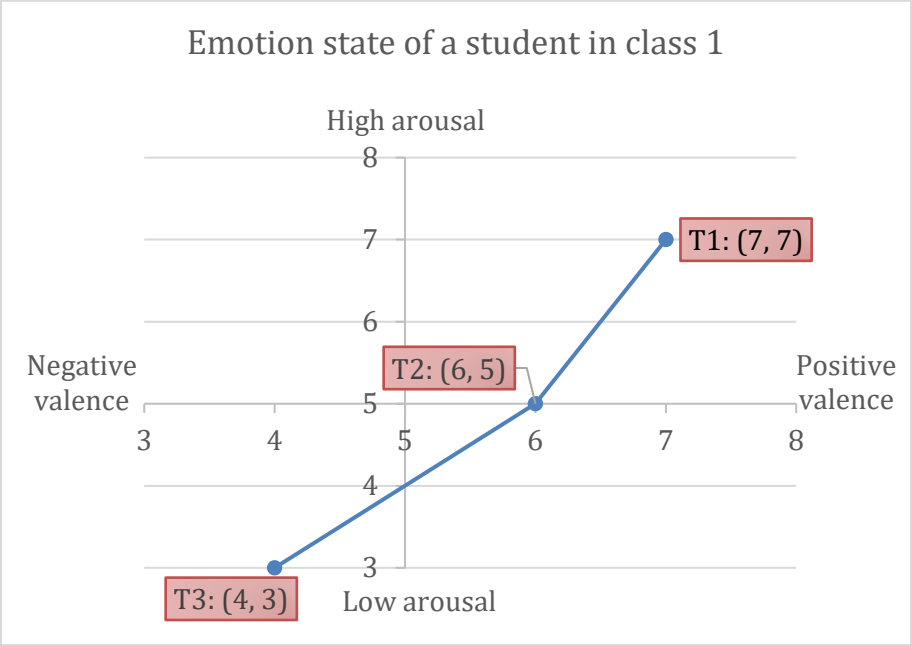

Figure 3.5 Arousal score and divergent-convergent task comparison

Table 3.2 Comparison of affect distance in process 1 and process 2 – paired sample t-test

Class	*n*	First task (Time 1 to Time 2)		Second Task (Time 2 to Time 3)		*t*	*P*
		M	*SD*	*M*	*SD*		
Class 1	22	2.05	1.25	1.20	0.96	2.65*	0.015
Class 2	21	2.61	1.32	1.46	1.09	2.70*	0.014
Class 3	20	1.70	0.74	2.16	1.13	-1.66	0.113
Class 4	22	1.91	1.59	1.28	0.84	2.10*	0.048

*$p < .05$, **$p < .01$. (2-tailed)

Table 3.2 also summarizes the results in the paired t-tests comparing the affect distance between the first and second tasks. In Class 1, Class 2, and Class 4, the distances were significantly larger in the first task than in the second task. In Class 1, the first affect distance ($M = 2.05$, $SD = 1.25$) was larger than the second distance ($M = 1.20$, $SD = 0.96$; $t\ (21) = 2.653$, $p < 0.05$). In Class 2, subjects' affect distance for the first task ($M = 2.61$, $SD = 1.31$) was larger than for the second task ($M = 1.46$, $SD = 1.09$; $t\ (20) = 2.70$, $p < 0.05$). In Class 4, the first affect distance ($M = 1.91$,

SD = 1.59) was larger than the second distance (*M* = 1.28, *SD* = 0.84; *t* (21) = 2.10, $p < 0.05$). These results support H2. Conversely, the convergent–divergent task combination in Class 3 showed the opposite, and the second distance appeared to be larger than the first, though the difference was not significant.

Additionally, we investigated the convergent–divergent intertwined task in Class 2 and Class 3. The distance of the first task in Class 2 was significantly greater than the distance of the first task in Class 3 ($t(19) = 3.342$, $p < 0.01$). The distances in the second task were not significantly different between Class 2 and Class 3. This result supports hypothesis 1.

3.5 Discussion

3.5.1 The influence of task types on affective experience

This study revealed salient evidence that taking part in divergent thinking tasks tends to have positive valence for participants. Average valence scores were all higher after performing the divergent tasks in the study than they were before performing the task. The affect change was statistically significant after the prototyping task in Class 3. Even though the change level of the positive affect in Class 4 was disguised, the dark-horse prototype ended with a higher valence level than the prioritizing theme and the prototyping task in Class 3. These results demonstrated the generality of a positive affect upswing (Akbari et al., 2012). Similarly, Håkonsson et al. (2015) argued that the positive affect was coincident with divergent thinking. However, their findings might indicate that people's satisfaction with the performance of their group will influence their affective experience during a creative task. Further research is needed to affirm this notion.

The influence of divergent tasks on affective experience includes increased arousal levels. Arousal was positively significant in all divergent task types except the dark-horse prototype. In

addition, the arousal level after the dark-horse prototype was the highest for all the tasks, and it was significantly higher than after the prioritizing theme task. The project-based creative design activities invited more movement, which likely led to a rise in the arousal levels. Moreover, group work likely encouraged the subjects to communicate their thoughts.

No correlation between the convergent tasks and affective experience appeared in this study. In Class 1, the average valence level gradually decreased after the subjects performed the two convergent tasks (i.e., synthesis and prioritizing theme). The average of the arousal level was increased slightly after the synthesis task, and then decreased after the prioritizing theme task. Meanwhile, in the classes that included divergent task types (i.e., Class 2 and Class 3), affect levels were increased evenly. While there were no significant negative affective experiences developed during the convergent tasks, the results showed that the affect changes during convergent tasks were not as significant as during the divergent tasks. This result is consistent with the findings of Amabile et al. (2005) that creativity, in general, evokes a positive effect. The incubation phase of creative output, defined as "a process of unconscious recombination of thought elements that were stimulated through conscious work at one point in time, resulting in novel and useful ideas at some later point in time," might influence the positive affect even weeks after a creative project (Amabile et al., 2005).

Albarracín and Wyer (2000) addressed that the impact of previous cognitive activity would be reduced by interfering in this activity. It would suggest us to arrange the intercede method to shift one task into another in the creative flow. This should be further studied in future researches.

One interesting result was that the performance of the Class 3 divergent task (i.e., prototyping) yielded increased levels of both valence and arousal consistently. The consistency of a positive affect escalation may be due to the activity performed in this task. Subjects were

equipped with various materials and working with all these materials might have fostered a sense of as well as fun. Moreover, the initial convergent task may have encouraged the subjects to perform the divergent task in a heightened state of arousal and appreciation because engaging in a selecting concept task helped to clarify what they were going to build in the prototype task. It is recommended that these phenomena be further investigated in future studies.

3.5.2 The influence of task order on affective experience

Subjects in the study exhibited greater affect change during their first task than during their second task. The difference was statistically significant in the convergent–convergent (Class 1), divergent–convergent (Class 2), and divergent–divergent (Class 4) task combinations. This result was consistent with the notion that the initial task made an impression on the completion of the second task. However, the convergent–divergent task set (Class 3) showed the opposite result. One possible explanation for this might be that the cognitive style of the second task (i.e., the divergent task) had a stronger influence on the affective experience than the cognitive style in the former task (i.e., the convergent task). This speculation offers a further point of inquiry for future investigations.

3.6 Chapter Summary

The current study presented two factors that may influence the affective experience in a group creative activity: the task type and the task order. The study results confirmed Akbari et al. (2012) assertion that divergent tasks swing affect to a positive level. This concept was shown not only in an ideation-like task (e.g., brainstorming), but also in prototyping tasks. Moreover, arousal emerged as one of the affective elements that increased by divergent thinking in group works. The

changes in arousal were more evident than in valence. Meanwhile, this study showed less affect change in convergent tasks.

The first task influenced affective experience more than the second task in most of the classes. This finding might indicate that the first process in a sequential creative task is the most potent time to awaken affective experience. It gives us a high opportunity to set affect to what extent we plan to. Nevertheless, divergent thinking has more flexibility to enhance the affective experience.

We come to a better understanding of how sequential creative tasks influences affect. Having this knowledge might help us to arrange a work process or event (e.g., learning, training) to evoke people's well-being.

We admit that conducting a real-case study might prevent us from uncovering the causality; thus, the vivid reason behind some phenomena could not be revealed. Hence, further research is needed to assist us in designing the affective creative flow.

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Chapter 4. The Effect of Creative Tasks on Affective Experience in Group Work[1]

4.1 Introduction

Chapter 3 focused on how the task type and task order in creative group work changes the affective state. The result showed that divergent tasks upswing affective state. Yet, we also found that the affective states did not necessarily decrease after convergent tasks. Some convergent tasks increased affective state, instead. We also find a suggestion that the convergent task can support the increase of the affective state in the divergent task that follows. Moreover, the effect of task orders appears inseparable from the type of task. Further investigation is needed to reveal the influence of these two factors on affective experience.

Chapter 3 also proposed to investigate the satisfaction factor toward the effect of group creative works on affective state. Håkonsson et al. (2015) argued that peoples' affective state during creative work was influenced by their own satisfaction toward their group performance.

This study attempted to examine the effect of the type and order of creative tasks on affective experiences during group creative work. We conducted an experimental study in which participants were involved in both divergent and convergent tasks in different orders. Affective states and group work satisfaction were measured as variables capturing the affective experiences of participants. The absolute score of affective experiences after task were compared between conditions. Having a better understanding of the creative task effect on affective experience in a group work might assist project leaders, managers, or instructors to develop a working system, maintain a good atmosphere and support engagement.

[1] This chapter is adopted from Amila, K., & Umemuro, H. (2022). The effect of creative tasks on affective experience in group work. *Journal of Japanese Ergonomics Society*, 56(6), 231-244.

4.2 Related Studies and Hypotheses

4.2.1 Creative tasks and affective experiences

Previous studies have revealed that creative tasks enhance positive affective experiences. Creative tasks provide people with the opportunity to express their opinions and make independent choices and thus enhance positive affective states (Bujacz et al., 2016). However, Zenasni and Lubart (2011) found that not all creative tasks were perceived as enjoyable. They suggested that the type of creativity task mediates the relation between the affective state and the creative process.

Akbari Chermahini and Hommel (2012) showed that, although insignificantly influenced arousal, divergent tasks improved positive valence, while convergent tasks tended to do the opposite. They suggested the concept of reciprocal relationships between affective state and cognitive control. The affective state and cognitive system are two different parts that work together (Gray, 2004). While the affective state might control some cognitive functions, the cognitive process might also influence the affective state. Previous studies revealed that a positive affective state broadens the scope of attention, thus fostering divergent task performance, whereas a negative affective state restricts attentional focus and therefore supports convergent task performance (Knörzer et al., 2016).

4.2.2 Creative tasks and affective states in group work

Creative processes conducted in group work are influenced by cognitive factors (e.g., to supply variation of ideas and experience; Stasser & Birchmeier, 2003) and social factors (e.g., to increase interest level and activity engagement; Amabile, 1983), which might be utilized to promote creativity. The fact that group work might also hinder the creative process is indisputable. We argue that the effect of creative tasks on affective experience might suffer from more complicated factors than individual work settings.

Group work requires that members be willing to share. Having more willingness to share extends the possibility for a group to be creative (Milliken, Bartel, & Kurtzberg, 2003). Sharing might strengthen the certainty of one's opinion through social comparison (Paulus & Brown, 2003). People receive feedback on their ideas from other members, compare their ideas to others, and thus create better ideas.

Nonetheless, the process of idea sharing might impede the cognitive process (Smith, 2003). Previous ideas may obstruct the generation of new ideas because ideas, particularly outstanding ideas, may restrict assumptions. The rise of an outstanding idea may hinder group members from finding more ideas. Group members may force themselves to attempt to create better ideas, and their self-evaluation of their own ideas may lead to blocked idea flows. Chirumbolo, Mannetti, Pierro, Areni, and Kruglanski (2005) mentioned that creative group work could be inhibited by evaluation apprehension (i.e., a concern over negative feedback from other members about their ideas) that leads to refraining from expressing opinions freely and to less motivation among group members. As a result, sharing, which is needed more in divergent tasks than in convergent tasks, might transform the affective state to a negative experience.

One way to prevent a group from blocking ideas is to invite diversity (Smith, 2003). However, a group with broader diversity is vulnerable to conflict, which may lead to negative affective experiences (Milliken et al., 2003). Background differences can also lead to misunderstandings about others' expectations, intentions, and opinions. As a divergent task requires a wide variety of ideas, members of a diverse group working on a divergent task might suffer from balancing the desire to maintain harmony by avoiding conflict and not delivering different opinions with the desire to share different opinions that might support creative performance (Nemeth & Nemeth-Brown, 2003).

On the other hand, members of a group tend to reach consensus and find similarity within their group work (Stasser & Birchmeier, 2003). Group discussion helps members focus on task goals and obtain consent that might be beneficial for convergent tasks (Nemeth & Nemeth-Brown, 2003). Having a question answered followed by positive feedback positively impacts the affective experience (Milliken et al., 2003).

Based on the above findings, we derive the following hypotheses:

H1a. In group work, participants rate the valence level of their own affect higher after performing a creative convergent task than after performing a divergent task.

H1b. In group work, participants rate the arousal level of their own affect higher after performing a creative convergent task than after performing a divergent task.

The task order might also impact affective experiences from tasks. The information and experience gained during the first task might influence the perception of the subsequent task. Milliken et al. (2003) argued that if groups experience a positive affective state in the first task, they tend to continue this positive experience by performing tasks that they consider to be supporting their group. On the other hand, if they experience a negative affective state in the first task, they might try to improve their group performance to avoid things that they experienced in the previous task.

In addition, the negative effect of diversity can be reduced by the time members spend together (Milliken et al., 2003). Time helps group members understand others' points of view and thus might create a comfortable atmosphere that supports divergent tasks. Performing a divergent task as the first task is prone to creating conflict because of differences and thus inviting a negative affective state, but people might experience a positive affective state after performing a divergent

task as the second task because they have shared their time while working together on the first task. By having a task preceding the divergent task, members might enhance their attachment so that they feel less hesitant to share their ideas afterward.

Based on the arguments above, we propose the following hypothesis:

H2. In group work, participants rate their affective state higher after performing the second creative task than after performing the first creative task.

4.2.3 Creative tasks and group work satisfaction

Briggs, Reinig, and de Vreede (2006) defined satisfaction as "affective arousal with a positive valence on the part of an individual toward some object." This is a subjective measure of group work success that is considered in addition to other objective measures (Pineda & Lerner, 2006). Satisfaction includes cognitive evaluation and an affective state (Judge & Klinger, 2008). In a group work context, satisfaction is a specific affective state, which is a positive valence at a high arousal level that emerges concerning group work activities. Satisfaction is an important aspect of work engagement and performance (Lawler & Porter, 1967).

Satisfaction, in accord with creativity, was often discussed in the context of workplace and organization. Meanwhile, the relationship between creative tasks and satisfaction is still obscure. We suppose that divergent tasks performed by groups would lead to lower satisfaction than convergent tasks performed by groups under the following conditions. First, impediments to idea generation might diminish group performance (Smith, 2003), causing members to feel dissatisfied. Second, divergent tasks show more diversity than do convergent tasks. Group members experience less satisfaction in a group that shows diversity (Milliken et al., 2003). Diversity increases emotional conflict and reduces group satisfaction levels (Milliken et al., 2003). If group members

avoid emotional conflict and strive to maintain their similarities and cohesion, their performance is obstructed.

The term group work satisfaction used in this study concerns momentary satisfaction experienced in short-term group work. Satisfaction can arise internally or externally (Håkonsson et al., 2016; Lawler & Porter, 1967). Accordingly, we adopt three variables in the meeting satisfaction model by Reinig (2003). One variable, which captures the internal factor, is individual goal attainment. This variable represents an individual's perception of how important the task he or she faced is and how much effort he or she put toward the task. The two remaining variables, which capture the external factor, are satisfaction with the process and satisfaction with the outcomes. Thus, we derive the following hypothesis:

H3. Participants rate perceived goal attainment, process satisfaction, and outcome satisfaction higher after performing a creative convergent task than after performing a divergent task.

The carryover effect of creative processes involves group satisfaction (Milliken et al., 2003). Thus, in line with the affective experience in Hypothesis 2, we propose the last hypothesis as follows:

H4. In group work, participants perceive higher work satisfaction after performing the second creative task than after performing the first creative task.

4.3 Method

4.3.1 Participants

Fifty-seven undergraduate students of an engineering school in Japan took part in this experiment as a partial fulfillment of the requirements of an engineering psychology course. There

were 42 males and 15 females, with a mean age of 20.0 years old (*SD* = 0.95). All students were proficient in the Japanese language, including Chinese characters (89.5% Japanese, 7% Chinese, 3.5% unspecified). Voluntary consent was obtained from all participants.

4.3.2 Design

Our experimental design included two fixed factors. The first factor was the type of creative task: divergent or convergent. The second factor was the order of the tasks: first or second. Accordingly, there were two creative tasks conducted in a series: the first condition was the divergent task followed by the convergent task, and the second condition was the convergent task followed by the divergent task. The order conditions were applied to participants nested in groups, as illustrated in Figure 4.1.

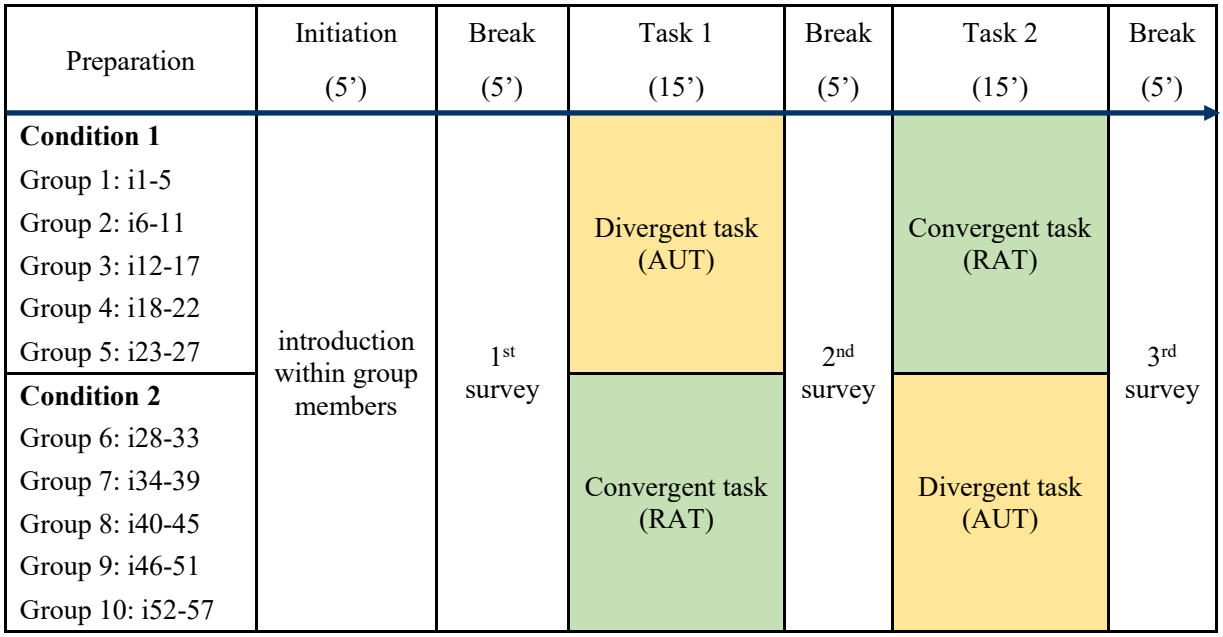

Figure 4.1 Experimental design and procedure. AUT = Alternate Uses Test, RAT = Remote Associates Test.

The divergent task used in this study was the alternate uses test (AUT; Guilford, 1967). Participants in a group were asked to write down as many possible uses of daily tools (i.e., bricks and a clip) as they could within a limited time. They were informed that there are no correct or

incorrect answers for this task. This test has mostly been used to test divergent thinking ability (Akbari Chermahini & Hommel, 2012; Forthmann et al., 2017; Runco & Acar, 2012; Visser et al., 2013). Bates and Gupta (2017) used this task to assess the idea generation ability of groups.

The convergent task used in this study was the remote associates test (RAT; Mednick, 1962). This study employed the Japanese version of the RAT (Terai, Miwa, & Asami, 2013). While the original RAT (Mednick, 1962) present three English concepts every trial and asked participants to identify the one concept that fits with all three, the Japanese RAT (Terai, Miwa, & Asami, 2013) presented participants three Chinese characters and asked them to identify one common Chinese character that can make a new idiom with each of the three Chinese characters presented. Sixty out of the original 79 trials were chosen randomly and applied in a fixed order so that each group had precisely the same tasks.

4.3.3 Procedure

Participants were assigned to one of ten groups of five to six people; their background and gender were considered to ensure that the conditions faced by all the groups were homogeneous. Each group had at least one and at most two female members. No more than one non-Japanese student was included in a group. Likewise, students from departments other than industrial engineering were not included in the same group.

Then, the groups were randomly divided into two order conditions of five groups each, resulting in 27 (male = 20, female = 7) participants in order condition 1 and 30 participants (male = 22, female = 8) in order condition 2. Groups in order condition 1 performed the divergent task first and then the convergent task. Meanwhile, groups in order condition 2 performed the convergent task first and then the divergent task.

Following the general explanation and instruction, participants broke up into their assigned groups and were asked to informally introduce themselves to other members of their group for five minutes so that they could recognize their peers. Then, participants were asked to complete the first questionnaire in five minutes, which contained demographic question items and an affect state assessment. A unique trace code was used to identify the same participants while keeping the responses anonymous.

Groups in order condition 1 performed the AUT first. Each group was provided with a sheet of A1-size paper and pen markers. In the first question, groups were instructed to write down as many uses of a brick as possible within 7 minutes. Then, in the second question, groups were asked to write down possible uses of a clip on the other sheet in the same way. The process was not described so that each group was able to arrange the working process as it wished. After the first task, participants individually completed the second questionnaire to assess the affective state and group work satisfaction in 5 to 10 minutes.

After the second questionnaire, the groups in order condition 1 conducted the RAT for 15 minutes. Sixty questions were displayed one by one on a screen of a PC provided for each group, and the answers were recorded on a sheet. Each group was able to control their working speed by autonomously clicking the “start” and “next” buttons to start and complete each question, respectively. A blank A4-size paper was provided for each member so that he or she was able to draft and show his or her ideas before writing one final response on the answer sheet.

After completing the second task, the participants completed the last questionnaire, which was the same as the second questionnaire. Finally, participants were debriefed and thanked.

Groups in order condition 2 conducted the two creative tasks inversely, i.e., the RAT as the first task and the AUT as the second task, and all of the remaining procedures were the same

as those in order condition 1. In both conditions, no feedback was given on either of the two tasks so that participants could not recognize whether the goal had been met when they provided their answers.

4.3.4 Measurements

4.3.4.1 Affective state

The Self-Assessment Manikin (SAM; Bradley & Lang, 1994) was employed to measure participants' individual affective states. Participants were asked to indicate their current affective state on a nine-point scale (valence: 1 = negative, 9 = positive; arousal level: 1 = low, 9 = high).

4.3.4.2 Group work satisfaction

The twelve-item meeting satisfaction scale of Briggs, Reinig and de Vreede (2006) was adopted to assess group work satisfaction. Three subscales were calculated from the responses, i.e., perceived goal attainment (GA), satisfaction with work process (SP), and satisfaction with work outcome (SO). Each subscale was calculated as the averages of responses for four question items such as "The work just now was worth the effort that I put into it", "I feel good about this work process", and "I liked the outcome of this work". Participants were instructed to evaluate their satisfaction with the latest task with each of items using seven-point Likert scales (1 = strongly disagree, 7 = strongly agree). Internal consistencies for GA, SP, and SO were $\alpha = .91$, $\alpha = .94$, $\alpha = .91$, respectively.

4.3.4.3 Creative performance

Responses for the AUT, as the score of the divergent task, were rated by three raters individually, not including experimenters. The rating included the objective scoring of uniqueness (Guilford, 1967) and the subjective scoring of uncommonness (Silvia, et al., 2008). For the uniqueness score, in each outcome, raters were asked to count the number of answers that were

different from other team responses. The average across all raters of the uniqueness score on the outcome of a group was considered as the final uniqueness score of a group. Interrater reliabilities of the three raters for the average measure was $\alpha = .88$.

For scoring of uncommonness, three items were used (e.g., “Ideas in this worksheet are different from other teams”). Raters rated the outcome of a group with each of three-item statements on a five-point Likert scale that ranged from “highly disagree” to “highly agree”, and the average rating of the three raters was used as the uncommonness score for the group. The internal consistency of the three items was $\alpha = .87$. The interrater reliability for the uncommonness dimension was $\alpha = .90$.

Meanwhile, the performance score of the convergent task of each group was the number of correct answers in the RAT. The maximum score was 60, and the minimum was 0.

4.3.5 Data analysis

The affective states and group work satisfaction data were analyzed using the linear mixed models in SPSS software (Version 19, IBM Corp.). The linear mixed model is a statistical method that can accommodate complex design such as nested (not independent) and repeated-measure data which are not possible to be analyzed with ANOVA and regression models (Bakdash & Marusich, 2017; Leech, Barrett, & Morgan, 2015). The model contains fixed variables as predictors and random variables. In this study, the affective states were measured on two dependent variables, namely, valence and arousal. Statistical analysis for these two variables was performed separately. Likewise, group work satisfaction was measured on three dependent variables, namely, GA, SP, and SO. The two predictors (i.e., task type and task order) were modeled using fixed effects. The value of task type was coded as “-0.5” for the divergent task and “0.5” for the convergent task. Likewise, the value of task order was coded as “-0.5” for the first

task, and "0.5" for the second task. Individual data measured repeatedly were analyzed at the first level and nested within a group at the second level of analysis. Thus, random effects included within-order, between-order, and between-group effects.

4.4 Results

4.4.1 Affective experience scores

Figure 4.2 and 4.3 show that the mean scores of all variables were higher after the convergent task than the divergent task except for the mean of valence in order 2. As shown in Table 4.1, the mean score of valences after the divergent task surpassed the mean valence score after the convergent task in the convergent-divergent task order.

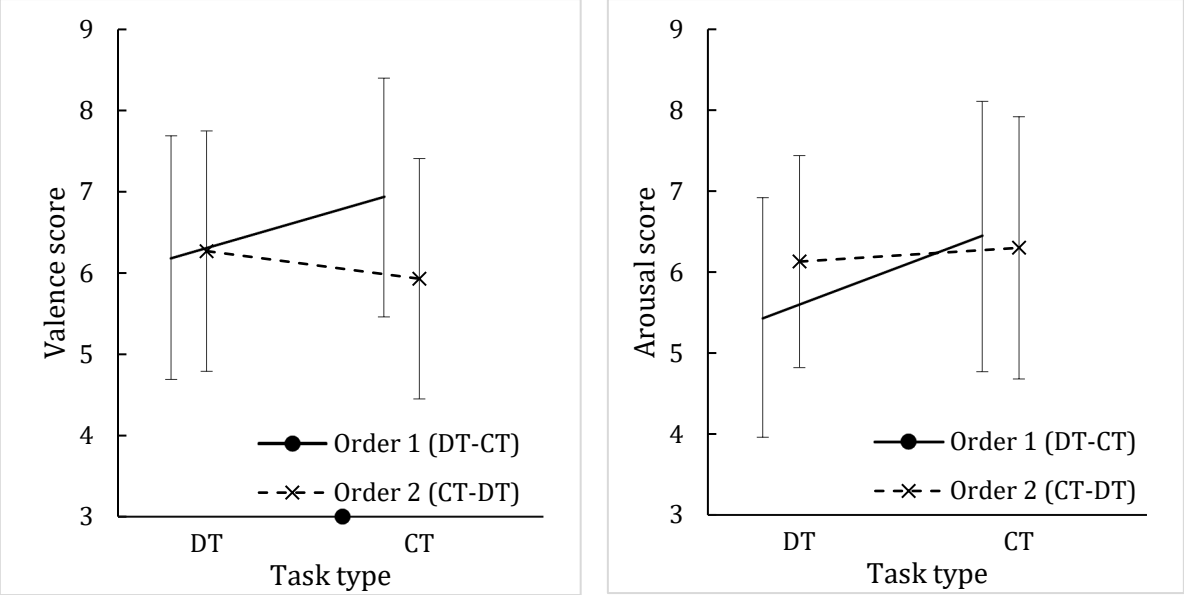

Figure 4.2 Means and standard deviations of affective scores by task type and order. Left is the valence level, and right is the arousal level. Vertical lines indicate standard deviations. DT = divergent task; CT = convergent task.

Figure 4.2 illustrates the scores of the valences and arousal after the divergent and convergent tasks for each task order. The mean scores of the valences after the divergent task were centered on six, whether the task was performed first or second. Meanwhile, mean scores of

valences after convergent task were contrasting. In the case in which the convergent task was performed first, the mean score of the valences after the task was lower than after the divergent

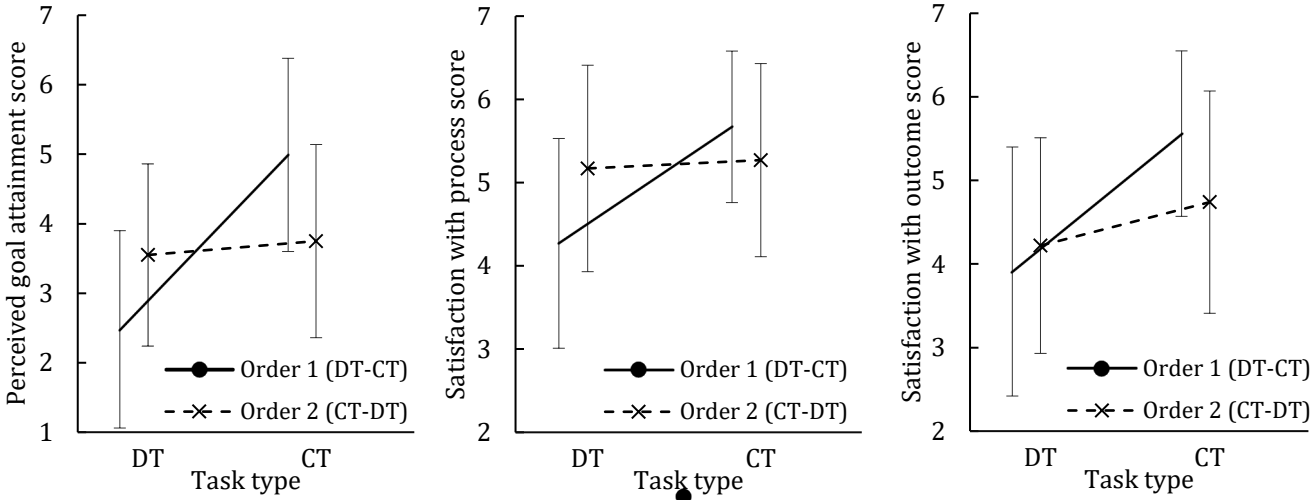

Figure 4.3 Means and standard deviations of group work satisfaction scores by task type and order. Left is the perceived goal attainment scores, center is satisfaction with the process scores, and right is satisfaction with the outcome scores. Vertical lines indicate standard deviations. DT = divergent task; CT = convergent task.

task. Contrarily, when the convergent task performed second, the mean score of the valences after the task was higher than after the divergent task. Both task order combinations revealed the superiority of the convergent task over the divergent task in elevating the arousal state. However, the slope is more evident in the divergent-convergent task sequence than in the convergent-divergent sequence.

Figure 4.3 illustrates the means and standard deviations of the three group work satisfaction scores, i.e., the goal attainment score, process satisfaction score, and outcome satisfaction score, respectively. Overall, the figures show a similar pattern in which the satisfaction level was higher after the convergent task than after the divergent task. Nevertheless, the distinction in the convergent-divergent task sequence is vague.

A series of Pearson correlation analyses indicated that there were significant positive correlations between overall valence and group work satisfaction scores: GA (r = .29, p = .002),

SP (r = .26, p = .005), and SO (r = .45, p < .001). Likewise, results of Pearson correlation analyses indicated that there were significant positive correlations between overall arousal and group work satisfaction scores: GA (r = .35, < .001), SP (r = .37, < .001), and SO (r = .46, p < .001). These results revealed that affective states are positively interconnected with group work satisfaction.

Our data revealed that the effects of task type and order on affective states and group work satisfaction were to a certain extent consistent with our hypotheses. We further conducted linear mixed models analyses to assess the plausibility of our hypotheses. About the initial score of affective states shown in Table 4.1, the Mann-Whitney U tests showed that there were no significant differences between the initial arousal of order 1 and order 2 (p = .66). Likewise, the initial valence of order 1 and order 2 were no significant difference (p = .06). The initial score of valence and arousal were excluded in our analysis to avoid redundancy. Yet, for the small p-value of the initial score, the further analysis of valence should be performed with caution.

Table 4.1 Means and standard deviations of affective states

	Affective State					
	Initial		After the Divergent Task		After the Convergent Task	
	M	*SD*	*M*	*SD*	*M*	*SD*
Order 1 (DT-CT)						
Valence	6.22	1.65	6.19	1.50	6.93	1.47
Arousal	4.33	1.59	5.44	1.48	6.44	1.67
Order 2 (CT-DT)						
Valence	5.43	1.25	6.27	1.48	5.93	1.48
Arousal	4.60	1.52	6.13	1.31	6.30	1.62

n Order 1 = 27, *n* Order 2 = 30; DT = Divergent Task, CT = Convergent Task

4.4.2 Unconditional model

Unconditional models were used to determine whether there was sufficient variability within and between random factors to require explanation. Table 4.2 shows that there was significant variability in the affective state and group work satisfaction measures. The valence

model revealed significant variability within-order (Wald Z = 6.06, $p < .001$) and between-order (Wald Z = 5.65, $p < .001$). Likewise, the arousal model showed significant variability within-order (Wald Z = 6.18, $p < .001$) and between-order (Wald Z = 4.81, $p < .001$). Meanwhile, for the group work satisfaction measures, only the satisfaction with work process (SP) model had significant variability within-order (Wald Z = 6.58, $p < .001$) and between-order (Wald Z = 2.82, $p = .005$). Only the within-order variabilities were significantly appeared in the perceived goal attainment model (Wald Z = 6.18, $p < .001$) and satisfaction with work outcome model (Wald Z = 6.18, $p < .001$). Although the group random effects were not significant, the variabilities due to the repeated factor suggest that the examination of conditional models would be beneficial. We expected that the task type and task order could explain some of these variabilities.

Table 4.2 Fixed and variance-covariance effect estimates of unconditional models for affective state and group work satisfaction

Parameter	Valence	Arousal	GA	SP	SO
Fixed effects					
Intercept	6.33 (0.26)***	6.08 (0.24)***	3.69 (0.23)***	5.10 (0.17)***	4.60 (0.22)***
Random effects					
Repeated measures					
Within-order variance	1.91 (0.31)***	2.15 (0.35)***	2.32 (0.32)***	1.46 (0.22)***	1.70 (0.24)***
Between-order covariance (rho)	0.55 (0.10)***	0.50 (0.10)***	-0.07 (0.14)	0.35 (0.12)**	-0.03 (0.14)
Between-group variance	0.41 (0.32)	0.29 (0.28)	0.32 (0.25)	0.10 (0.14)	0.32 (0.22)

Note. Standard errors are in parentheses. **$p < .01$. ***$p < .001$.

4.4.3 Conditional model

The conditional models were used where creative task type (divergent task or convergent task) and task order (first task or second task) were set as the fixed factors.

Table 4.3 shows that task order ($F(1, 55.0) = 11.29$, $p = .001$) was a significant predictor of valence, while the task type effect was not significant. A likelihood ratio chi-square indicated that the change in -2 restricted log-likelihood of 7.98 (df =2) was significant (p =.019). Accordingly, the conditional model of valence with task type and task order as predictors was reasonably

superior to the unconditional model. The positive estimated value of task order effect showed that the valence scores were higher in the second task than in the first task. This result rejected H1a yet supports H2.

The effects of task type ($F(1, 55.0) = 11.30$, $p = .001$) and task order ($F(1, 55.0) = 5.76$, $p = .020$) were significant predictors of arousal. A likelihood ratio chi-square indicated that the change in -2 restricted log-likelihood of 11.39 ($df = 2$) was significant ($p = .003$). This result revealed that the conditional model of arousal that included task type and task order as predictors explained significantly more variance than did the unconditional model. The positive estimated value of the task type and task order effects indicated that the convergent task and the second task would increase level of arousal, respectively. As a result, H1b and H2 are supported.

Table 4.3 Fixed and variance-covariance effect estimates of conditional models for affective state and group work satisfaction, with task type and task order as predictors

Parameter	Valence	Arousal	GA	SP	SO
Fixed effects					
Intercept	6.33 (0.26)***	6.08 (0.24)***	3.69 (0.23)***	5.10 (0.17)***	4.59 (0.22)***
Task type	0.20 (0.16)	0.58 (0.17)**	1.35 (0.19)***	0.75 (0.13)***	1.09 (0.19)***
Task order	0.54 (0.16)**	0.42 (0.17)*	1.15 (0.19)***	0.65 (0.13)***	0.56 (0.19)**
Random effects					
Repeated measures					
Within-order variance	1.84 (0.31)***	2.04 (0.34)***	1.59 (0.24)***	1.24 (0.21)***	1.36 (0.20)***
Between-order covariance (rho)	0.61(0.089)***	0.58 (0.09)***	0.35 (0.12)**	0.59 (0.09)***	0.21 (0.13)
Between-group variance	0.41 (0.32)	0.29 (0.28)	0.32 (0.25)	0.10 (0.14)	0.32 (0.23)

Note. Standard errors are in parentheses. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 4.3 also shows the significant effects of the task type and order on group work satisfaction. The effect of tasks type ($F(1, 55.0) = 51.00$, $p < .001$) and the task order ($F(1, 55.0) = 37.05$, $p < .001$) were significant predictors of perceived goal attainment. A likelihood ratio chi-square indicated that the change in -2 restricted log-likelihood of 49.72 ($df = 2$) was significant ($p < 0.001$). This result reveals that the conditional model of the perceived goal attainment that

included task type and task order as predictors explained significantly more variance than did the unconditional model.

Likewise, the effect of task type ($F(1, 55.0) = 31.20$, $p < .001$) and task order ($F(1, 55.0) = 23.81$, $p < .001$) were significant predictors of the satisfaction with work process. A likelihood ratio chi-square indicated that the change in -2 restricted log-likelihood of 33.67 ($df = 2$) is significant, $p < .001$. This result revealed that the conditional model of the satisfaction with the work process that included the task type and task order as predictors explained significantly more variance than did the unconditional model.

Finally, the effects of task type ($F(1, 55.0) = 31.06$, $p < .001$) and task order ($F(1, 55.0) = 8.30$, $p = .006$) were significant predictors of satisfaction with the work outcome. A likelihood ratio chi-square indicated that the change in -2 restricted log-likelihood of 26.90 ($df = 2$) was significant, $p < .001$. This result revealed that the conditional model of satisfaction with the work outcome that included the task type and task order as predictors explained significantly more variance than that of the unconditional model. The positive estimated value of task type and task order effects represented that the group work satisfaction scores would be high in the condition of the convergent task and in the second task. Accordingly, H3 and H4 were supported.

We also analyzed using an alternative conditional model that included the task type and the interaction of task type and task order as predictors. The effect of task type ($F(1, 56.0) = 26.08$, $p = .317$) and the interaction between task type and task order ($F(1, 8.1) = 0.79$, $p = .399$) were not significant predictors of valence. While the effect of task type ($F(1, 56.0) = 9.6$, $p = .003$) was significant predictors of arousal, the interaction between task type and task order ($F(1, 8.0) = 0.33$, $p = .580$) was not significant. Similarly, the effect of task type ($F(1, 56.0) = 28.4$, $p < .001$) was significant predictors of perceived goal attainment, while the interaction between task type and

task order ($F(1, 8.0) = 0.02$, $p = .882$) was not significant. The effect of task type ($F(1, 56.0) = 20.2$, $p < .001$) was significant predictors of the satisfaction with work process, while the interaction between task type and task order ($F(1, 7.9) = 0.56$, $p = .476$) was not significant. The effect of task type ($F(1, 56.0) = 26.1$, $p < .001$) was significant predictors of the satisfaction with work outcome, while the interaction between task type and task order ($F(1, 7.9) = 0.28$, $p = .613$) was not significant.

4.4.4 Creative performance scores

We used group scores to analyze the relationship of creative performance and affective experience scores. Each of group performance scores represented creative performance of a group as a whole, while affective experience scores and satisfaction scores were averaged across participants in each group. The uniqueness score of AUT ranged between 25.00 as the highest and 1.50 as the lowest and 4.50 as median. The highest uncommonness scores of AUT was 3.94, the lowest was 1.50, and the median was 2.28. The RAT scores were 56.00 at highest, 44.00 at lowest, and 52.50 at median. Figure 4.4 summarizes creative performance scores of the group separated by order condition. Order 1 comprised Group 1 to 5 which performed divergent task and convergent task in sequence, while order 2 consisted of Group 6 to 10 that performed convergent task first then divergent task.

A series of Spearman's rho correlation analyses indicated that there were no significant positive correlations between overall group creative performance scores and affective state scores ($r_s < .52, p > .12$). As for the group work satisfaction, a significant positive correlation was shown between uniqueness and perceived goal achievement ($r_s = .66$, $p = .038$), while the other correlations were not significant ($r_s < .62, p > .05$). Likewise, scatter plot analysis could not suggest any specific relation patterns neither.

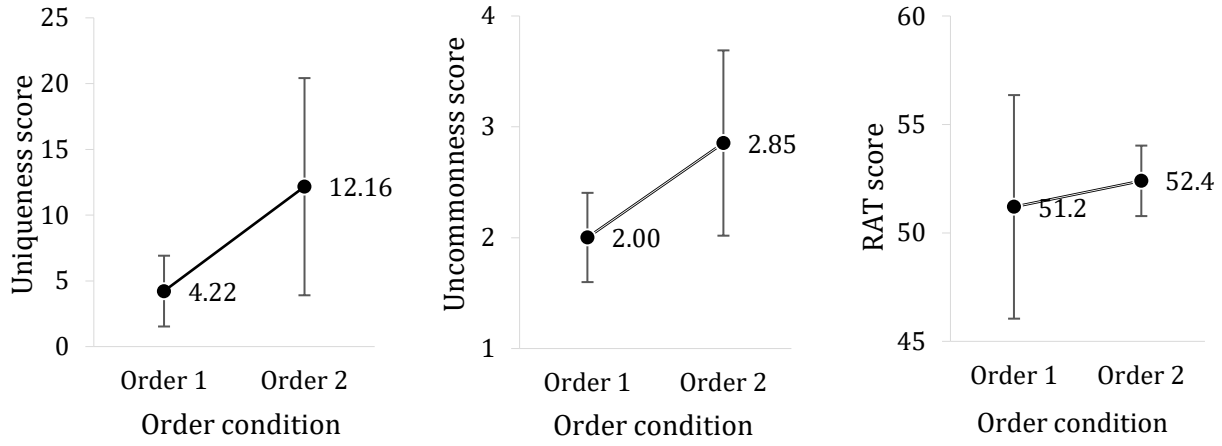

Figure 4.4 Means and standard deviations of group creative performance scores by order condition. Left is the uniqueness scores, center is uncommonness scores, and right is RAT scores. Vertical lines indicate standard deviations.

4.5 Discussion

This study aimed to investigate the effect of the type and order of creative tasks on affective state and satisfaction in group work. We suspected that a convergent group task invites higher valence and arousal as well as satisfaction levels than a divergent group task. At the same time, the affective state and group work satisfaction was expected to be influenced by the order of the creative tasks.

4.5.1 Affective state

The current study revealed that the creative task type did not cause a significantly different effect on individual valence levels in group work. Both the divergent and convergent task provoked moderately positive valence. The possible reason could be that creative tasks, in general, enhance positive valence (Bujacz et al., 2016). In addition to the freedom to express ideas and choices such tasks involve (Bujacz et al., 2016), group work might bring new insight and unique ideas from others, and stimulate people to express their opinions, which might then incite enjoyment (Nijstad,

Diehl, and Stroebe, 2003). Group work might also increase positive valence through the acceptance and endorsement of one's ideas by other members (Paulus & Brown, 2003). On the other hand, each of these tasks has challenges that might restrain the increase of positive valence. For instance, the blocking effect that constrains group members in expressing ideas not only appears in idea generation tasks such as brainstorming but also during problem-solving tasks such as the RAT (Smith, 2003).

Our results confirm that the convergent task elevated arousal significantly more than the divergent task conducted in a group. This finding supports the argument that group work might confound divergent task processing. Both the cognitive factor (e.g., information processing) and social factor (e.g., motivation) in group work might hinder creativity, especially in the divergent (Nemeth & Nemeth-Brown, 2003). Often people involved in generating ideation in a group think that they have the same idea as one already mentioned by another group member, which might thus reduce the involvement of group members (Nijstad et al., 2003). Meanwhile, group work naturally fits the nature of convergent tasks. Group work encourages people to solve a problem by consensus (Stasser & Birchmeier, 2003) so that group members attempt to express their answer, even if the answer is the same, to strengthen the group's decision.

The results also confirm that task order influences the affective state. This study showed that the task order has a significant effect on the valence level. The second creative task elevates valence more than the first creative task, regardless of the task type. People tend to maintain their valence in a more positive state after their second task. The linear mixed model also showed that the factor of task order had a significant effect on the arousal level, although the interaction between task order and task type was not significant. The second task elevated higher arousal than the first task. These results corresponded to the previous studies mentioned that the previous

affective state underlies the motivation to perform well on the subsequent creative task (Adler & Obstfeld, 2007) and thus to maintain the affective state (Milliken et al., 2003). Milliken et al. (2003) surmised that as time goes by, group members may be more emotionally engaged, increase their support for other members, and thus have an elevated positive affective state.

This result might indicate that creativity in group work could offer different affective states compared with individual work. Affective states such as enjoyment and pleasure come from intrinsic motivation, which is accommodated more by individual tasks than group tasks Hennessey (2003). However, this study did not directly compare creative group and individual work. Hence, further research might be needed to verify the difference in effect between creative group work and creative individual work on the affective state.

This study found no correlations between affective state and creative performance scores. Although the result differed from some previous studies (Davis, 2009; Isen, Daubman, & Nowicki, 1987; Newton, 2013; Zenasni & Lubart, 2002; Zenasni & Lubart, 2011), Akbari Chermahini & Hommel (2012) found a similar result that affective states induced by creative tasks were independent of task performance. This result might show that an affective state as a consequence of creative task provides a different effect on creative performance than an affective state which is prepared as a controlled factor. However, considering the small number of samples in this study, further researches with a large sample are needed to confirm this notion.

4.5.2 Group work satisfaction

As expected, participants expressed more satisfaction after the convergent task than after the divergent task. The goal attainment, process satisfaction, and outcome satisfaction were all higher after the convergent task than after the divergent task. This result might be indicative of the nature of group work in terms of relations between members' effort and the results. In convergent

tasks, the effort people put forth might be more proportional to the value they obtain, whereas performing the divergent task in group work might require more effort than the value they obtain. This is in line with the notion that in divergent tasks, people might be overwhelmed with the various processes (e.g., listening to others, participating in the discussion, selecting information, and providing ideas) given their cognitive limitations (Nijstad et al., 2003). Likewise, divergent tasks are susceptible to idea blocking (Smith, 2003) and emotional conflict because of diversity (Milliken et al., 2003), which might result in reduced group work satisfaction.

Furthermore, members' activities, such as arranging the group work process and determining an answer, might be more evident in convergent tasks than in divergent tasks. Therefore, convergent tasks may invite the higher satisfaction of members through those evident activities. This consideration is consistent with the nature of group work, which leads to consensus rather than to varying ideas (Stasser & Birchmeier, 2003).

Likewise, the task order influences the group work satisfaction level. Similar to the arousal, the linear mixed model also revealed that the second task increased group work satisfaction levels. This result supports the notion that group work satisfaction is involved in the carryover effect of the creative process (Milliken et al., 2003).

The current study revealed that the interaction of task types and task orders did not cause a difference in the level of satisfaction between two conditions. In the DT-CT condition, the convergent task coincided with its position as the second task which both supported to increase group work satisfaction, hence the satisfaction was obviously higher in the first than in the second task. However, the level of group work satisfaction in the CT-DT combination is almost the same because of the increase in satisfaction induced by the convergent task being hampered by its first

position, and the decrease in satisfaction caused by the divergent task being held back by its position at the end. Still, this is a conjecture that needs to be investigated in the future study.

The results show that the effect of task type and task order was more consistent for the group work satisfaction level of analysis than for the general affective state, particularly the valence level. These results might imply that the effect of creative task type and task order might be more apparent in the specific affective experience than in the general valence-arousal level. These results confirm our notion that it is necessary to include group work satisfaction variables to gain more understanding of how divergent and convergent tasks affect people's affective experience.

Our study revealed a positive correlation between perceived goal attainment and uniqueness. The high interest and effort put into the creative work process increases the number of ideas and thus the chances of a unique notion arising. Meanwhile, other variables did not show any correlation. No performance feedback in this study could be a factor in the discrepancy between satisfaction score (subjective score) and performance score (objective). Still, the small number of samples in this study prevents us from the conclusion.

4.5.3 Conclusion and limitations

This study revealed some important points regarding the effect of creative task factors on affective state and satisfaction in creative group work. Specifically, the creative task type and task order influence the affective state as well as group work satisfaction. The results of this study may imply that when designing creative group tasks in practice, we should pay attention to the order of the different tasks that will be conducted continuously. The results suggest that performing a convergent task may have an advantage to increase group members' engagement and group work satisfaction. Meanwhile, the second task might be beneficial to elevate overall affective experience,

particularly valence, in creative group work. Still, the effects of the task type and task order interaction should be further studied and understood, for better management and improvement of the affective experience in creative group work.

The current study has some limitations. First, our limited number of sample points causes low statistical power. In addition, our participants had little diversity of backgrounds, which might restrict the generalizability of the findings. Second, the present study focused only on the AUT and RAT. There are various kinds of creative tasks that differ in terms of the figures, symbols, or behaviors (Guilford, 1967), which might have different effects on affective experience. Third, our study focused only on two task orders combining divergent and convergent tasks reciprocally. Future studies should consider more combinations, including divergent-divergent task sets and convergent-convergent task sets, in addition to the combinations adopted in this study.

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Chapter 5. General Discussion

This chapter discusses some interesting points from our three studies of creativity in group work, including some conforming and conflicting results.

5.1 Affective State and Creative Performance

The most common notion about the correlation between affective state and creative performance is that performance in creative tasks is positively correlated with valence (e.g., Amabile, Barsade, Mueller, & Staw, 2005; Zenasni & Lubart, 2011). Particularly, positive valence is beneficial to improve divergent performance (e.g., Lewis & Lovatt, 2013; Yamada & Nagai, 2015). Chapter 2 revealed varying results. While the investigation rejected the notion in almost all phases, arousal showed a greater connection with divergent performance. Chapter 4 did not show any positive correlation between affective experience and divergent performance, except between internal satisfaction and uniqueness. Potential reasons and improvement areas for the methodology are discussed as follows.

5.1.1 Level of analysis

These results might suggest the contrast effect of creativity performed individually and collaboratively in a group. Working in a group emerge a social factor that diminish the correlation between affective state and group performance. Tsai, Chi, Grandey, and Fung (2012) found that when group members highly trust with their group and had positive affective states, they were at risk of self-complacence and lead to low creative performance. Still, studies about affective experience in collaborative creative work are limited, thus requires more investigation in the future.

5.1.2 Affective state manipulation

Another potential reason is the spontaneous affective state in both studies. The spontaneous affective state refers to emotions that occur necessarily, without manipulation or conditioning, after work processes and interactions in groups and classes. Chapter 2 captured generalized emotions, which predominate during each learning process (1-2 weeks). While Chapter 4 assessed affective state after each task. Both studies indicated no significant correlation between divergent performance of group work and unmanipulated affective state. Still, this speculation needs to be examined through further research, involving manipulated affective state and larger number of samples.

In Chapter 4, the average divergent score of groups with order condition 2 was higher than groups with order condition 1. If we assume that the order condition manipulated the affective state, then we might suggest that the higher level and positive change of affective state would elevate group divergent performance. This hypothesis is in line with the notion that positive affect is suitable to share ideas in group (Collins, Lawrence, Troth, & Jordan, 2013). However, small number of samples prevent us from the conclusion. Further study is significant to examine this notion.

Various methods to manipulate the affective state can be adopted. Grawitch, Munz, Elliott, and Mathis (2003) controlled the affective state at the individual level. They asked participants to remind of a pleasant event they had recent time for positive affect condition, and a neutral event for neutral affect condition. Then, participants were assigned to one group. Visser, van Kippenberg, van Kleef, and Wisse (2013) showed that affective state displayed by a leader could regulate followers' affect. Hence, individual or group manipulation of affective state can be considered.

The time members spent together in the group or in the class should also be a consideration. The notion of a positive correlation between affective state and group divergent performance might apply to a new cohort. Meanwhile, for the group that members have been together for a certain time, the trust factor, as we mentioned in 5.1.1, might restrain the correlation. This is just our speculation that requires further research.

5.1.3 Creative performance scoring

This dissertation involved two kinds of creative activities; creative work in a design thinking class as discussed in Chapter 2 and creative work in conventional form as in Chapter 4. The use of objective scoring such as number of ideas produced in divergent task (fluency) and number of ideas that differ from other groups (originality) were common for a conventional divergent task (e.g., Lewis & Lovatt, 2013) or a simple brainstorming task (e.g., Grawitch et al., 2003). Yet, to decide whether an idea is original, we still need rater's judgment. The scoring is becoming more complex in creative problem-solving tasks such as design thinking. The number of process produce numbers of group outcome. Besides, the interest of each group about a case might be different, hence comparing the outcome between groups was impractical. Thus, we applied systematic scoring with subjective rating in Chapter 2 and Chapter 4.

Still, the subjective scoring is susceptible to dissent. Different background and experience might influence the judgment. In addition, the judges have to deal with several outcomes with different concentrations. Further study is needed to develop a more practical scoring system.

There are many ways to assess creative performance, such as expert judgment. Tsai et al. (2011) asked team leader to assess group creativity. It might also involve potential users in deciding a creative product. However, the choices are restricted and the final product should be visible. Thus, revealing the relationship between step-by-step creative processes, which are

divergent and convergent processes, and affective state might be challenging. Further study should consider these issues. In addition, we need qualitative research to gain profound insight of creative group work.

5.2 Affective State on Sequential Tasks

Chapter 3 and Chapter 4 explored the effect of sequential tasks on affective experience. Chapter 3 involved four combinations of divergent-convergent tasks and focused on the change of affective state. It revealed that divergent tasks upswing affective state. The effect was found more significantly in the arousal state. Moreover, except in the convergent-convergent task combination, the overall affective states terminated at the highest point of valence and arousal. The change of affective state in the first task was greater than the second task. However, the convergent-divergent task combination showed an opposite result. The affective state after convergent task was upswing greater than after divergent task. We suspected that convergent tasks have a significant role in regulating affective state in group work.

Accordingly, Chapter 4 followed up on the results of Chapter 3 by simplifying the task into two contrasting tasks and using the conventional divergent and convergent tasks. The use of conventional, independent creative tasks is necessary so that the assessment of the role of the task type is more objective and prevents bias from the influence of one task on another. We also considered about social factors in group creative work and derived the hypotheses of Chapter 4 accordingly. Chapter 4 disclosed that, in general, the affective states terminate in a higher level in a second task than a first task. Chapter 4 revealed a contrasting result from Chapter 3 that the convergent task generated higher arousal than the divergent task. Still, Chapter 4 strengthened our

notion that convergent tasks might help to maintain affective states. The potential reasons for different results between both studies are discussed as follows.

5.2.1 Variety of creative activities

Chapter 3 and Chapter 4 involved different creative tasks. The contents of divergent and convergent tasks in Chapter 4 are not linked to each other, while Chapter 3 involved tasks in succession. As the consequences, although we analyzed the affective states in each class independently, the design thinking stage prevented us to gain data of affective state after divergent tasks in the initial stage. The first divergent task was in Class 2, which had been preceded with convergent task, and participants had spent a couple of weeks working together in a group. Future study may consider involving a series of over two independent tasks, comparing with the pattern revealed in Chapter 3. Future study might also compare between group with unacquainted members and acquainted members.

5.2.2 Cultural difference

The difference in participants is also worth to be considered. Study in Chapter 3 involved larger diversity of students than in Chapter 4. Participants in Chapter 4 were only Japanese and Chinese, while Chapter 3 had more than half non-Japanese students, including students from Europe. The diversity of students might bring attractiveness in divergent tasks. The existence of cultural difference, which might generate different perception toward creative tasks type, needs further study.

5.3 Arousal in Creative Group Work

The three studies in this dissertation revealed the significant involvement of arousal in creative group work. Chapter 2 showed the correlation between arousal level and divergent

performance. Chapter 3 disclosed that divergent tasks elevate the level of arousal. Chapter 4 pointed out that the arousal state was higher after convergent than divergent task and after the second task than the first task. These aligned results, that emerge the existence of arousal in creative group work, assert the differences of the affect-creativity relationship at the individual and group level. Group work can attract involvement and maintain persistence in creative activities. As creativity is expected to produce innovative products, it requires many stages of the process and takes a long time. Hence, the effort, involvement, and persistence are needed, and the elevation of arousal, as long as not to the extreme point, is beneficial.

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Chapter 6. Conclusions

6.1 Summary of Dissertation

The dissertation aimed to formalize the relationship between affective experience and creative group work in a higher education learning. Affective experience included the two cores of affective states, namely valence and arousal, and satisfaction. We classified creative processes based on the cognitive theories of creativity, i.e., divergent, and convergent thinking. Three studies involved in this dissertation were developed based on the notion of reciprocal affect-creativity relationship.

Overall, the relationship between affective experience and creative group work can be explained as follows. First, affective experiences are associated with divergent thinking performance. Chapter 2 showed some association between arousal and divergent score, while Chapter 4 exhibited the connection between internal satisfaction and uniqueness. Second, creative group works impact affective experiences. These studies considered two factors of creative process, including task type (divergent or convergent) and task order (the first or the second). Chapter 3 denoted that both factors influence affective experience in a group work. Divergent tasks swing altered arousal positively. The changes of affective states were higher in the first task than the second task. Chapter 4 revealed that two independent creative tasks, in which each task produces output that is not related to each other, sway affective experience. Regarding the task type, convergent task elevated arousal level. As for the task order, both valence and arousal were higher after the second task.

6.2 Research Implications

This dissertation delivered better understanding about how group work influences the connection between affective experience and creative activities. Group works cause the arousal dimension as an important point in creative process. The arousal dimension is correlated with creative performance, and also influenced by creative thinking process. This formulation can be the underpinning for further research related to affect and group creativity.

Some suggestions are made for development of creativity teaching or training, notably in higher education. Our studies indicated that creative group work influences students' engagement, motivation, and effort. Chapter 3 revealed significant changes in arousal after divergent tasks of the design thinking project. Chapter 4 showed that performing a traditional convergent task (i.e., RAT) in a group increases the level of arousal. Meanwhile, Chapter 2 conveys that medium-high arousal relates with high creative performance. Hence, we might manage creative activities as a group work to promote intensive participation. However, we also need to consider that group work will consume a lot of energy, so it requires time control and breaks between processes.

6.3 Limitations and Future Studies

This dissertation has shown the relationship between affective experience and creative group work in real classroom conditions. These studies bridge the basic concepts of a cognitive theory of creativity with project-based learning. However, the studies have several limitations that can be grouped as two major aspects: the sample and the methodology. Details of limitations and suggestions of alternative methodologies and directions for future studies are described as follows.

6.3.1 Limitation of the sample

Some limitations of the sample should be taken into consideration. First, in the actual classes, the number of students who enrolled and attended the classes cannot be controlled, as well as their participation in the studies were voluntary. Hence, collecting data from actual classes resulted in small numbers of sample size. Besides, variety of the samples were restricted. Our study conducted in Japan. Even though some of our participants were international students, the atmosphere of the class and the domination of Japanese students might control their perception. Further studies are needed to increase the number and the variety of samples.

6.3.2 Limitation of the methodology

Based on literature studies discussed before, affective experiences might influence creative performance in group work. For instance, positive valence and moderate-high arousal would elevate divergent performance, while negative valence and moderate-low arousal were expected to downswing convergent performance. Chapter 2 revealed a positive relationship between arousal level and divergent performance. Chapter 3 showed that satisfaction in goal achievement is positively correlated with uniqueness. However, the studies could not express the causality. The suggestion for further research is to control the affective state factor. By controlling affective state, besides disclosing the cause-and-effect relationship, we may also have a wider range of affective level hence we could gain more insight about this issue.

Regarding the creative performance, the scoring method is complex and challenging. Besides the number of categories, raters' background might also be an obstacle to gain consensus. The further research should devise a simpler method to assess creative group work. Further study

might also collaborate with companies and involving more experts to gain more comprehensive knowledge.

Creativity in a group work is complex phenomena. The scope of research discussed in this dissertation is the basic elements of creativity, i.e., process and person. Hence, other factors that might influence affective experiences in creative group work were neglected. A further exploration of other factors such as individual difference, trust, and creative instruments, and their effects on different kinds of divergent tasks should be counted for consideration.

Acknowledgements

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I would also like to thank Indonesia Endowment Fund for Education (LPDP) for the four-year financial support, through which I got the opportunity to complete this study.

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Last but not least, a special thank you to my lovely husband (your turn will come and, *Insya Allah*, you can do it), my hearty parents, my generous brother, my kind-hearted sister, and other family members whose faith, pray, and constant support fuel these endeavors. May the Almighty recompense you with goodness.

Appendix A. Example of affective state and emergence leadership perception questionnaire (Chapter 2)

Design Thinking Questionnaire

(Emotion & Leadership - 5)

General Instructions

The purpose of this study is to examine the effect of group's emotion and leadership on design thinking class performance. This questionnaire asks about your feeling and perception **during "Dark Horse" prototyping.**

Think of this past one week, starting from "Dark Horse" prototyping introduction until today's group activity. Then, answer all questions below according to your own experience/perception. Your information will be kept confidential and will NOT affects your final grade.
Thank you for your cooperation.

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User Code Instruction
In order to tract change overtime, individuals are required to provide unique **User Code**. Your **User Code** contains two alphabets and two numbers with the following rule:

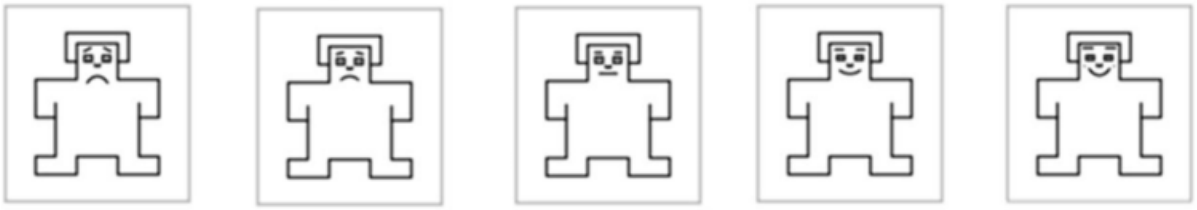
[first letter of your mother's first name] + [first letter of your birth city] + [two last digits of your Student ID]

Example: Emily + Tokyo + 18M12017 = ET17

User Code	
Group Name	

Part I. Think of this past one week until today, working on "Dark Horse" prototyping activities. Circle (O) the most appropriate number for each following question.

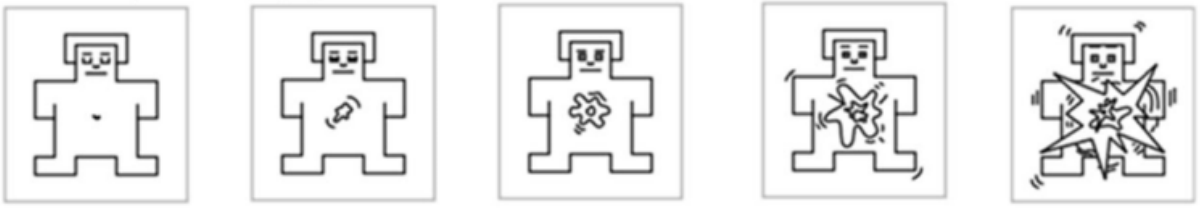
1. Which of the following picture represent your emotional valence mostly best?



1 2 3 4 5 6 7 8 9

Negative/ clearly distressed — Neutral — Positive/ obviously elated

2. Which of the following picture represent your emotional arousal mostly best?



1 2 3 4 5 6 7 8 9

Low arousal/ very calm/ boredom — Neutral — High arousal/ bursting/ excitement

Part II. Think of this past one week until today, working on "Dark Horse" prototyping activities. The leftmost column of table below describes about how often your group engage in the experiences. Indicate your response to each item by circling (O) one of the five numbers on the answer column using this scale:

1	2	3	4	5
Never	Seldom	Occasionally	Often	Always

Statement	Answer				
	Never				Always
Your group experiences hard time related to group work.	1	2	3	4	5
Your group experiences hard time related to member relationship.	1	2	3	4	5

Part III. Think of this past one week until today, working on "Dark Horse" prototyping activities. The leftmost column of table below describes about how often at least one of your group members (including yourself) engage in the behaviors. Indicate your response to each item by circling (O) one of the five numbers on the answer column using this scale:

1	2	3	4	5
Never	Seldom	Occasionally	Often	Always

Statement	Answer				
	Never				Always
tells group members what they are supposed to do	1	2	3	4	5
acts friendly with members of the group	1	2	3	4	5
sets standards of performance for group members	1	2	3	4	5
helps others feel comfortable in the group	1	2	3	4	5
makes suggestions on how to solve problems	1	2	3	4	5
responds favorably to suggestions made by others	1	2	3	4	5
makes his or her perspective clear to others	1	2	3	4	5
treats others fairly	1	2	3	4	5
develops a plan of action for the group	1	2	3	4	5
behaves in a predictable manner toward group members	1	2	3	4	5
defines role responsibilities for each group member	1	2	3	4	5
communicates actively with group members	1	2	3	4	5
clarifies his or her own role within the group	1	2	3	4	5
shows concern for the personal well-being of others	1	2	3	4	5
provides a plan for how the work is to be done	1	2	3	4	5
shows flexibility in making decisions	1	2	3	4	5
provides criteria for what is expected of the group	1	2	3	4	5
discloses thoughts and feelings to group members	1	2	3	4	5
encourages group members to do quality work	1	2	3	4	5
helps group members get along with each other	1	2	3	4	5

This is the end of this questionnaire. Thank you for your cooperation.

Appendix B. Example of divergent and convergent task assessment form (Chapter 2)

DESIGN THINKING RATING SHEET
(Ideation & Concept Development)

General Instruction

This sheet will be used to evaluate groups' outcome by the end of Ideation & Concept Development activity. Group outcome will be categorized into two ways of thinking, divergent thinking and convergent thinking.

Part I. Divergent thinking objective is to generate creative ideas as many as possible. In Ideation & Concept Development activity, brainstorming outcome will be measure as the result of divergent thinking. You will receive a number of measurement tables along with separated brainstorming outcome. State your rating on the score column.

Part II. Convergent thinking objective is to generate a single appropriate idea or correct solution. In this phase, developed concept will be measure as the result of convergent thinking. You will receive a number of measure tables consist of item measurements along with separated concept output. State your rating on the score column.

Thank you for your cooperation.

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Rater Code

Before go on to the next page, please fill in the following columns with your own information.

first letter of your mother's first name	first letter of your birth city	two last digits of your Student ID

Assessed Group

Name : Eye-Power
Challenge :
"Design an Innovative Experience with Bank for Young Generation of **Foreigners in Japan**"

Part I. Divergent Thinking

For **each table** below, indicate your rating by circling (O) one of the five numbers in the score column.
Please make sure that you rate the same brainstorming output as stated in the table.

Brainstorming 1.
How might we let users experience bank services without Japanese knowledge?

Measurement Item	Score				
	Highly disagree				Highly agree
Ideas in this brainstorming map are different each other	1	2	3	4	5
Each idea in this brainstorming map occur infrequently	1	2	3	4	5
Ideas in this brainstorming map are similar each other	1	2	3	4	5
These ideas conceptually distant from obvious	1	2	3	4	5
These ideas are usually used in daily life	1	2	3	4	5
Hardly imagine these ideas (WOW)	1	2	3	4	5
These ideas never have existed before	1	2	3	4	5
These ideas are smart	1	2	3	4	5
These are interesting ideas	1	2	3	4	5
These ideas are challenging	1	2	3	4	5
These ideas are plain/unattractive	1	2	3	4	5
Eagerly looking forward the concept that converted from these ideas	1	2	3	4	5

Brainstorming 2.
How might we offer an innovative experience for foreigners that stay for different time periods?

Measurement Item	Score				
	Highly disagree				Highly agree
Ideas in this brainstorming map are different each other.	1	2	3	4	5
Each idea in this brainstorming map occur infrequently	1	2	3	4	5
Ideas in this brainstorming map are similar each other	1	2	3	4	5
These ideas conceptually distant from obvious	1	2	3	4	5
These ideas are usually used in daily life	1	2	3	4	5
Hardly imagine these ideas (WOW)	1	2	3	4	5
These ideas never have existed before	1	2	3	4	5
These ideas are smart	1	2	3	4	5
These are interesting ideas	1	2	3	4	5
These ideas are challenging	1	2	3	4	5
These ideas are plain/unattractive	1	2	3	4	5
Eagerly looking forward the concept that converted from these ideas	1	2	3	4	5

Brainstorming 3.
How might we give users the opportunity to use bank services from anywhere and anytime?

Measurement Item	Score				
	Highly disagree				Highly agree
Ideas in this brainstorming map are different each other.	1	2	3	4	5
Each idea in this brainstorming map occur infrequently	1	2	3	4	5
Ideas in this brainstorming map are similar each other	1	2	3	4	5
These ideas conceptually distant from obvious	1	2	3	4	5
These ideas are usually used in daily life	1	2	3	4	5
Hardly imagine these ideas (WOW)	1	2	3	4	5
These ideas never have existed before	1	2	3	4	5
These ideas are smart	1	2	3	4	5
These are interesting ideas	1	2	3	4	5
These ideas are challenging	1	2	3	4	5
These ideas are plain/unattractive	1	2	3	4	5
Eagerly looking forward the concept that converted from these ideas	1	2	3	4	5

This is the end of Divergent Thinking Rating Sheet.

Go on to the next page for Convergent Thinking Rating Sheet

Part II. Convergent Thinking

For **each table** below, indicate your rating by circling (O) one of the five numbers in the score column.
Please make sure that you rate the same concept as stated in the table.

Concept 1.
Concept Name: Robot Friend
HMW Addressed: HMW let users experience bank services without Japanese knowledge?

Measurement Item	Score				
	Highly disagree				Highly agree
This concept name contains similar term with idea that come up in brainstorming	1	2	3	4	5
This concept derived from some similar ideas that come up in brainstorming	1	2	3	4	5
This concept has an unexpected relationship with the HMW addressed	1	2	3	4	5
This concept unexpectedly may solve the challenge	1	2	3	4	5
This concept converts ideas from brainstorming into something new	1	2	3	4	5
This concept is built from combining several different ideas that come up in brainstorming	1	2	3	4	5
This concept is relevant to HMW addressed	1	2	3	4	5
This concept has a function that solves the HMW	1	2	3	4	5
This concept is very likely to complete the challenge	1	2	3	4	5

Concept 2.
Concept Name: Body Bank
HMW Addressed: HMW let users to use bank services anytime and anywhere?

Measurement Item	Score				
	Highly disagree				Highly agree
This concept name contains similar term with idea that come up in brainstorming	1	2	3	4	5
This concept derived from some similar ideas that come up in brainstorming	1	2	3	4	5
This concept has an unexpected relationship with the HMW addressed	1	2	3	4	5
This concept unexpectedly may solve the challenge	1	2	3	4	5
This concept converts ideas from brainstorming into something new	1	2	3	4	5

This concept is built from combining several different ideas that come up in brainstorming	1	2	3	4	5
This concept is relevant to HMW addressed	1	2	3	4	5
This concept has a function that solves the HMW	1	2	3	4	5
This concept is very likely to complete the challenge	1	2	3	4	5

Concept 3.
Concept Name: Electronic Bank Paper (EBP)
HMW Addressed: HMW give users the opportunity to use the bank service from anywhere and anytime?

Measurement Item	**Score**				
	Highly disagree				Highly agree
This concept name contains similar term with idea that come up in brainstorming	1	2	3	4	5
This concept derived from some similar ideas that come up in brainstorming	1	2	3	4	5
This concept has an unexpected relationship with the HMW addressed	1	2	3	4	5
This concept unexpectedly may solve the challenge	1	2	3	4	5
This concept converts ideas from brainstorming into something new	1	2	3	4	5
This concept is built from combining several different ideas that come up in brainstorming	1	2	3	4	5
This concept is relevant to HMW addressed	1	2	3	4	5
This concept has a function that solves the HMW	1	2	3	4	5
This concept is very likely to complete the challenge	1	2	3	4	5

This is the end of this rating sheet. Thank you for your cooperation.

Appendix C. Example of demographic information and emotion questionnaire (Chapter 3)

Design Thinking 2018 Questionnaire

(Demographic Information)

General Instructions

The purpose of this study is to investigate the relationship between emotional state and creative design thinking processes. To this end, we kindly request that you complete this demographic survey and the further separated emotional state sheet.

Do NOT write your name on this questionnaire. Your responses will be anonymous and will never be linked to you personally. To track the change over time, we will provide one column for User Code instead. Your participation is voluntary. All your responses will be kept confidential and will NOT affect your final grade.

Thank you for your cooperation.

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Doctoral Student
Supervised by UMEMURO Hiroyuki
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User Code Instruction
Before go on to the next page, please fill in the following columns with your information.

first letter of your mother's first name	first letter of your birth place	two last digits of your cell phone

Example: Nobita + Tokyo + 070 2345 6789 = NT89

Go on to the next

Demographic Information

Please fill in the blank and circle the response that best describes you.

1. Gender : a) Male b) Female

2. Age : _____ years old

3. Faculty/Department :

_____

4. Student grade level :

a) Master 1st year b) Master 2nd year c) Research Student d) other _____

5. Nationality :

_____

Design Thinking 2018 Questionnaire

(Emotion: Day 1, Part A)

User Code Instruction
Please fill in the following columns with your information.

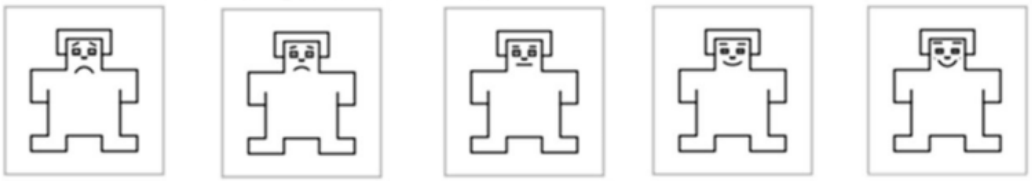
first letter of your mother's first name	first letter of your birth place	two last digits of your cell phone

Example: Nobita + Tokyo + 010 2345 6789 = NT89

Your Group Name

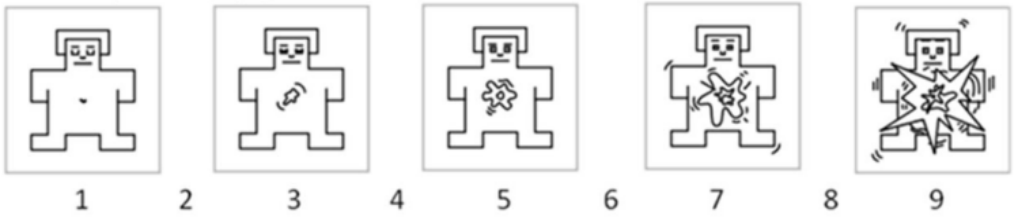
Please rate your current feeling using the two set of pictures below. Circle (O) the most appropriate number below the picture.

1. Pleasure level



Negative/clearly distressed Neutral Positive/obviously elated

2. Activation Level



Low arousal/very calm/quiet Neutral High arousal/bursting/excitement

The end of this questionnaire. Please fold up this paper after you finish.

Appendix D. Example of affective state and satisfaction perception questionnaire (Chapter 4)

Engineering Psychology 2018 Questionnaire
(Form B: Affect State)

User Code Instruction
Please fill in the following columns with your information.
回答を始める前に、指示に従って以下の表を埋め、ユーザーコードを作成して下さい。

first letter of your mother's first name あなたのお母様の名前の最初のアルファベット	**first letter of your birth place** あなたの出身地の最初のアルファベット	**two last digits of your cell phone** あなたの携帯電話の最後 2 桁の番号

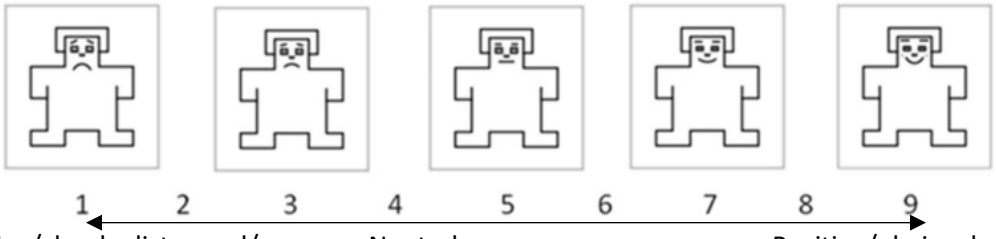
Example: Shizuka + Chiba + 010 2345 6789 = SC89

Your Group Number/グループ号

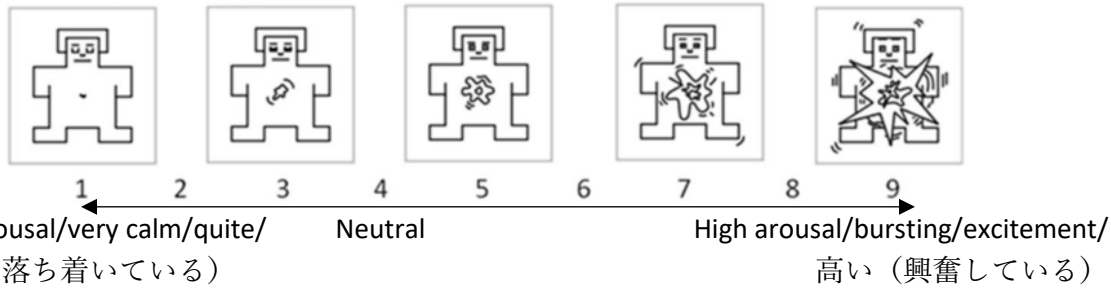
Part 1. Individual Affect State

Please rate your current feeling using the two set of pictures below. Circle (O) the most appropriate number below the picture. あなたの現在の感情状態について、下の 2 つのイラスト群を用いて教えてください。イラスト下にある番号を見て、あなたの状態に最も近いものに◯をつけて下さい。

1. Pleasure level/ 快・不快



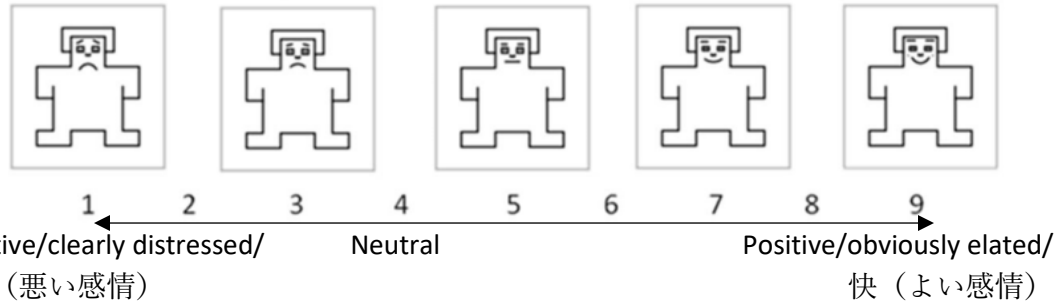
2. Activation Level/ 覚醒度



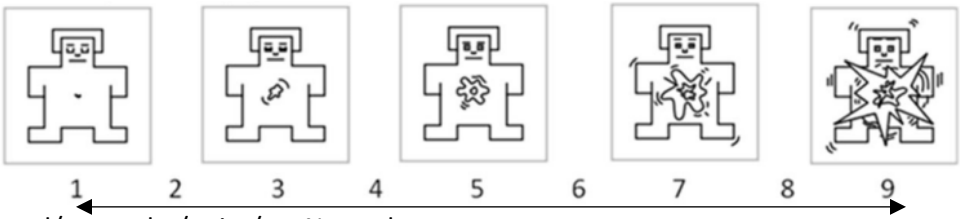
Part 2. Group Affect State

Based on your perception, please rate how you perceive the current affect state of **your group** using the two set of pictures below. Circle (O) the most appropriate number below the picture. あなたのグループ全体船体の感情状態についてどう思いますか、下の 2 つのイラスト群を用いて教えてください。イラスト下にある番号を見て、あなたのグループの状態に最も近いものに◯をつけて下さい。

1. Pleasure level/ 快・不快



2. Activation Level/ 覚醒度



Part 3. Group Work Satisfaction

The following items evaluate the **group work** you have experienced **just now**. Please circle (O) a number which represents your answer most. 以下の質問項目は、**たった今**行なわれた**グループワーク**に関する質問です。あなたの回答に最も近い数字に〇をつけて下さい。

Item/質問項目	Answer/回答						
	strongly disagree 全く そう思わない			Neutral どちらでも ない			strongly agree とても そう思う
The work just now was worth the effort that I put into it. 今のワーク(仕事・作業)は、頑張っただけの価値があるものだったと思う。	1	2	3	4	5	6	7
The things that were accomplished in the work warranted my effort. ワーク(仕事・作業)を通して成し遂げたことは、私の努力に見合っていた(努力を保証してくれた)。	1	2	3	4	5	6	7
The results of this work were worth the time I invested このワーク(仕事・作業)の結果は、費やした(投資した)時間の分の価値がある。	1	2	3	4	5	6	7
The value I received from this work justifies my efforts このワーク(仕事・作業)を通してえた価値は、私の努力が正しかったことを証明してくれた(努力を正当化してくれた)。	1	2	3	4	5	6	7
I feel satisfied with the way in which this work was conducted このワーク(仕事・作業)の実施方法に満足している。	1	2	3	4	5	6	7
I feel good about this work process このワーク(仕事・作業)のプロセスは良かったと思う。	1	2	3	4	5	6	7
I feel satisfied with the procedures used in just now task 与えられたタスク（ワーク？）の手順に満足している。	1	2	3	4	5	6	7
I feel satisfied about the way we carried out the activities in this task 現在のタスク(ワーク？)の進め方に満足している。	1	2	3	4	5	6	7

Item/質問項目	Answer/回答						
	strongly disagree 全く そう思わない			Neutral どちらでも ない			strongly agree とても そう思う
I liked the outcome of this work. ワーク(仕事・作業)の成果物が好きだ。	1	2	3	4	5	6	7
I feel satisfied with the things we achieved in this work ワーク(仕事・作業)を通して達成した内容に、満足している。	1	2	3	4	5	6	7
When the task was finally over, I felt satisfied with the results. ワーク(仕事・作業)が終わった後、満足の行く結果だと思った。	1	2	3	4	5	6	7
I am happy with the results of this work ワーク(仕事・作業)の結果に対して、嬉しく思っている(喜ばしい気持ちだ)。	1	2	3	4	5	6	7

The end of this questionnaire.
これでアンケートは終わりです。

Appendix E. Example of divergent task assessment form (Chapter 4)

DIVERGENT THINKING RATING SHEET

Dear Rater,

We appreciate your help in evaluating this creative work. This sheet will be used to assess the outcome of the Alternate Uses Task which is an assessment of divergent thinking. Divergent thinking objective is to generate creative ideas as many as possible.

You will face the work of 10 teams responding two mission of The Alternate Uses Task. The work of 10 teams will be assessed in each mission separately. Please fill in the form provided on the following pages.

Do not hesitate to ask if you have any questions. Thank you for your cooperation.

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Mission I.

The 10 teams were asked to solve the following mission:

Please take a few minutes to look at all the group works responding to this mission.

If you are ready, you may go to the next page.

Mission I - Team 1.

In this part, you will assess the **Team 1** work on **Mission 1**. Please focus on the Team 1 working sheet, and complete the questions listed below.

1. How many answers do you find in this worksheet?
このワークシートに回答はいくつありましたか？
2. If these answers are classified into several groups, how many groups do you find?
回答をいくつかのグループに分類するとすると、いくつのグループになりますか？
3. How many answers in this worksheet are different from other teams' response?
他のチームの回答には見られなかった回答は、いくつありますか？
4. Indicate your rating of this working sheet in the measurement item below by circling (O) one of the five numbers in the scoring column. Please read the measurement items carefully.
このワークシートを、以下の項目に従って評価してください。それぞれの項目を注意深く読んで、一つに丸をしてください。

Measurement Item	Score				
	Highly disagree				Highly agree
Ideas in this worksheet are different from other teams. このワークシートのアイディアは他のチームのものと違う。	1	2	3	4	5
This worksheet contains ideas that infrequently occur in the other worksheets. このワークシートには、他のチームでも頻繁に出てくるアイディアが含まれている。	1	2	3	4	5
There are a lot of similar responses with ideas in this worksheet that is given by other teams. このワークシートのアイディアと似た回答は他のチームからもたくさん出ていた。	1	2	3	4	5
Most of the ideas in this worksheet are given only once among all responses to this mission (including other teams work). このワークシートのアイディアのほとんどは、他のチームのものも含めても一度しか出てこないものだ。	1	2	3	4	5
Ideas in this worksheet are unexpected. このワークシートのアイディアは予想もできないものだ。	1	2	3	4	5
Ideas in this worksheet are not real. このワークシートのアイディアは現実世界には未だないものだ。	1	2	3	4	5
I have never seen these ideas in the normal uses. これらのアイディアは、通常の使い方の範囲では見たことがない。	1	2	3	4	5
I can find similar ideas to those listed on this worksheet in everyday use. このワークシートに書かれているアイディアは、日常の使い方でも似たような考えを見かける。	1	2	3	4	5
These ideas are insightful. これらのアイディアは示唆に富んだものた。	1	2	3	4	5
These ideas give me a new perception. これらのアイディアは新しい見方を与えてくれる	1	2	3	4	5
These ideas are entertaining. これらのアイディアはとても楽しい。	1	2	3	4	5
These ideas are plain/unattractive これらのアイディアは平凡で面白くない。	1	2	3	4	5