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The effect of problem solving approaches on creativity, fixation, and enacted task complexity.

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Abstract

The purpose of this experimental study was to investigate the effect of problem solving approaches on the creative process and the creative outcome. Particularly, we explored the effect of action-oriented problem solving, unconscious thought, and analytical thought on creativity, enacted task complexity, and fixation. The effect of an incubation period was investigated as a potential moderator in the relation between problem solving approaches and creativity and between problem solving approaches and fixation. Participants included 129 students from BI Norwegian Business School who completed the nine-dot problem. Results showed that participants in the unconscious thought condition performed significantly better than participants in the analytical thought condition and the action-oriented problem solving condition, followed by the analytical thought condition. Furthermore, results showed that participants in the analytical thought condition became significantly more fixated than the two other conditions during the problem solving process. Results did not support the moderating effect of an incubation period. The insights obtained in this study may help organizations facilitate individual creativity, which today is considered one of the most important drivers of growth, innovation, and success.

1.0 Introduction

Creativity is considered an important driver for organizational growth, innovation, and success (Zhou & Hoever, 2014). Recent changes in the nature of work have contributed to a greater need for creativity in employees (Shalley, Gilson, & Blum, 2009). Some of these major shifts include increased global competition, job restructuring, and decentralization of hierarchical structures in organizations (Shalley, Gilson, & Blum, 2009). Creativity has been described as a key factor for operating successfully in dynamic environments, developing new capabilities, and responding to challenges (Zhou & Hoever, 2014). Although creativity has been researched for more than 50 years, there is no universally accepted definition of the concept (Isaksen, Dorval, & Treffinger, 2011). However, most definitions describe creativity as the generation of ideas or products that fulfill the criteria of novelty and appropriateness in any given context (Hennessey & Amabile, 2010).

In more recent years, researchers and scholars have taken an inclusive approach in understanding creativity, acknowledging that it is a natural characteristic of human beings (Isaksen, Dorval, & Treffinger, 2011). It was not uncommon to think that individuals high in creativity were geniuses or especially gifted and talented (Isaksen, Dorval, & Treffinger, 2011; Amabile & Pillemer, 2012). Research gradually recognized that other factors, such as motivation, pressure, constraints, and the social-environment, had an influence on creativity (Amabile & Pillemer, 2012). Today, creativity is widely accepted as a skill that can be learned, trained, and improved (Amabile & Pillemer, 2012). The key issue is to understand how to use and develop this creativity (Isaksen, Dorval, & Treffinger, 2011; Amabile & Pillemer, 2012). Some areas of interest in creativity research have been to investigate various problem solving approaches and potential antecedents and inhibitors of creativity (Shalley, Gilson, & Blum, 2009; Hennessey & Amabile, 2010).

Problem solving is closely linked to creativity. Problem solving is defined as “the process of closing the gap between what is and what is desired” (Isaksen, Dorval, & Treffinger, 2011, p. 19). Problems can be either well-defined or ill-defined. In well-defined problems, the problem solver operates in a closed space where the criteria for choosing what paths to follow are clear and narrow (Dörner & Funke, 2017). In contrast, ill-defined problems are often referred to as complex, because they lack a clear problem definition, an ultimate goal, and a clear set of

means to solve them (Dörner & Funke, 2017). In other words, there is more liberty in choosing what paths to follow (Dörner & Funke, 2017). A creative approach to problem solving is often used to solve ill-defined problems (Isaksen, Dorval, & Treffinger, 2011). Such an approach implies that the problem solver is advancing towards a novel, structured, and open-ended outcome (Isaksen, Dorval, & Treffinger, 2011).

Research has investigated the effect of certain problem solving approaches on creative performance (Dane, Baer, Pratt, & Oldham, 2011). Problem solving has by some been explained as an active and exploratory process (Simon, 1996; Rudolph, Morrison, & Carroll, 2009). Some researchers have found that making active attempts when searching for problem solutions leads to more creative solutions than simply applying standardized solution alternatives (Kaufmann 1979; Kaufmann & Raaheim, 1973). Others have found that unconscious thought leads to more creative solutions and ideas than conscious thought, particularly when faced with complex tasks (Zhong, Dijksterhuis, & Galinsky, 2008; Dijksterhuis & Meurs, 2006). However, relatively little research attention has been paid to comparing the effects of multiple approaches on creativity.

Closely associated with problem solving is incubation. An incubation period refers to the time in which an unsolved problem is taken a break from (Smith & Blankenship, 1991). The idea behind putting an unsolved problem aside for a period of time, is that temporary distraction may create sudden insight into the problem solution (Smith & Blankenship, 1991). An incubation effect is said to occur if sudden insight occurs following the incubation period (Smith & Blankenship, 1991). Research suggests that distraction from an unsolved problem may be particularly helpful when an individual gets fixated on incorrect solution approaches (Smith & Blankenship, 1991; Sio & Ormerod, 2009; Baird et al., 2012). However, the research findings on incubation are inconsistent. While some studies support the incubation effect, suggesting that distraction from an unsolved problem is helpful when fixated thinking occurs (Smith & Blankenship, 1991; Baird et al., 2012), other studies have found no effect (Olton & Johnson, 1976).

Another set of research has explored the relation between complexity and creativity. Some researchers propose that task complexity is determined by an individual's subjective perception and enactment of the task (Hærem, Pentland, & Miller, 2015), which implies that a task can be as complex as an individual sees it (Chae, Seo, & Lee, 2015). Sia and Appu (2015) found that high task complexity

was a significant positive predictor of creative performance. In another study, Zhou, Hirst, and Shipton (2012) found that perceived problem solving demand, an aspect of job complexity, was positively related to employee creativity.

The limited research into the role of problem solving approaches on both the creative process and the creative outcome, suggests that there is a need for additional insight. The approaches addressed in previous research, that are of interest in the present thesis, include action-oriented problem solving, unconscious thought, and analytical thought. This thesis takes an exploratory approach to investigate the relation between problem solving approaches and creative task performance. In addition, we seek to explore whether certain problem solving approaches might be more effective than others in facilitating the creative process. Particularly, we are interested in learning which approaches might be more useful for reducing fixation and increasing enacted task complexity, as both have been linked to creativity. Lastly, we will test the potential moderating effect of an incubation period on enhancing creative task performance and reducing fixation.

With the increasing global competition and the dynamic business-environment that organizations operate in today, learning how to facilitate for novel, original, and valuable solutions is critical for organizations to build and maintain competitive advantage. Given the widely accepted idea that creativity is a skill that can be practiced and strengthened, the aim of this thesis is to contribute to our understanding of how organizations can promote individual creativity. By exploring how three distinct problem solving approaches impact both the creative outcome and the creative process, we seek to increase our knowledge of how organizations can be more effective in exploiting the creative potential of their individual employees when faced with ill-defined and complex problems.

2.0 Theoretical background and hypotheses

2.1 Creativity

Researchers and scholars have paid great attention to understanding the human ability to generate new ideas, approaches, and solutions (Hennessey & Amabile, 2010). However, research on creativity has been referred to as “a scientific disaster area” (Kaufmann, 2003, p. 235) due to the ambiguous definitions and terminologies used (Isaksen, Dorval, & Treffinger, 2011). Multiple theories and

frameworks have been developed as an attempt to explain the complexity involved in creativity (Isaksen, Dorval, & Treffinger, 2011).

The dominant focus among early researchers of creativity was on personality-traits and talents (Amabile, 1983; Isaksen, Dorval & Treffinger, 2011). Amabile's (1983) research on the social psychology of creativity offered a more comprehensive understanding of the concept. Her componential framework takes into account the interactions between the social-environment, personality characteristics, and cognitive skills (Amabile, 1983). It suggests that the three intra-individual components that influence creative responses or production, are domain-relevant skills, creativity-relevant skills, and task motivation (Amabile, 1983; Amabile & Pillemer, 2012). Each of these intra-individual components can be influenced by the social environment (Amabile & Pillemer, 2012). Another comprehensive framework is the 4P's model, which describes creativity in terms of four overlapping themes often identified in literature (Isaksen, Dorval, & Treffinger, 2011). The themes include the creative person, the creative process, the creative product, and the press or place in which creativity occurs (Isaksen, Dorval, & Treffinger, 2011). The 4P's model suggests that each theme influences the other themes, and that all themes must be taken into consideration in order to get a complete understanding of creativity (Isaksen, Dorval, & Treffinger, 2011). However, most contemporary definitions focus on the creative product, where creativity is evaluated in terms of outcome (Amabile, 1983). Therefore, we will adopt Amabile's (1983) definition of creativity and evaluate a creative outcome in terms of novelty and appropriateness to the task at hand.

For the purpose of this thesis, it is useful to also mention the level-style distinction, which offers two perspectives on creativity. Level refers to the ability to be creative, where creativity is measured in terms of the degree of performance (Haukedal & Kuvaas, 2007). Style refers to how an individual prefers or tends to be creative, and concerns the mental processing involved when being creative (Haukedal & Kuvaas, 2007). In other words, style is linked to the creative process identified in the 4P's model. Style can be measured in terms of manner of performance (Haukedal & Kuvaas, 2007). Research suggests that people can adapt to different kinds of thinking, such as rational or intuitive, that will enable them to achieve creative solutions (Dane, Baer, Pratt, & Oldham, 2011). This thesis seeks to understand whether some cognitive styles and problem solving approaches are more effective than others when it comes to facilitating the creative process.

2.1.1. Insight problems

Insight problems are often used in problem solving and creativity research. Insight problems require individuals to replace or restructure their initial solution strategies with alternative ones, in order to find a specific solution to the task at hand (Sio & Ormerod, 2009). Such problems are ill-defined because the means for achieving the solution is not obvious (Beatty, Nusbaum, & Silvia, 2014). Extensive search through large problem spaces is often required for solving insight problems (Martinsen, Furnham, & Hærem, 2016). For the purpose of this study, we will use the nine-dot problem, a classic, yet difficult insight problem (MacGregor, Ormerod, & Chronicle, 2001).

2.2 Problem solving

The process of problem solving involves answering questions or finding solutions to tasks that present concerns, challenges, or opportunities (Isaksen, Dorval, & Treffinger, 2011). In order to find novel and appropriate responses to problems, “active and simultaneous consideration of opposites” (Isaksen, Dorval, & Treffinger, 2011, p. 23) are essential. The following section discusses two distinct cognitive styles. Next, cognitive styles are linked to various problem solving approaches, and their relations to creativity, enacted task complexity, and fixation are discussed.

2.2.1 Cognitive style

Kirton (1976) proposes that an individual’s cognitive style can be identified somewhere on a continuum ranging from adaptive to innovative. He explains that adaptors seek to solve problems in risk-averse, familiar, and efficient ways, while innovators tend to challenge well-established rules and approach solutions from several angles. In line with this, Kaufmann (1979) differentiates between assimilators and explorers. Assimilators tend to follow a rational strategy, where they attempt to solve novel problems with minimal effort and by stretching established principles as far as possible (Kaufmann, 1979). Explorers, on the other hand, search for novel solution alternatives through the explorer strategy, regardless of the novelty or complexity of the task at hand (Kaufmann, 1976). In his study, Kaufmann (1979) found support for the idea that assimilators more frequently relied

on standard solutions than simple solutions, compared to explorers who showed a preference for simple solutions. Results further showed that the explorers' performance in terms of finding correct solutions to a task, was superior to the assimilators' performance. Kaufmann (1979) suggests that a possible interpretation of these findings is that explorers are more flexible in terms of spontaneously shifting their problem solving alternatives.

2.2.2 Action-oriented problem solving

Simon (1996) describes the process of problem solving as being similar to a maze, as it requires trial, error, and selectivity. He explains that human beings explore among several alternative paths, evaluate to which extent the explored paths represent progression towards the goal, and make decisions of either continuing or abandoning specific paths based on the evaluation of their usefulness. The more novel or difficult a task is to solve, the more trial and error it will require (Simon, 1996). Rudolph, Morrison, and Carroll (2009) explain a similar process in their model of an interactive feedback loop that describes the adaptive processes of action-oriented problem solving. The first step of the loop is taking action, which generates new cues and information that becomes available for interpretation. The second step concerns interpreting the new cues and information, while the last step involves cultivating new solutions and either confirming or disconfirming the initial solution on the basis of the interpretation of the incoming information in the previous steps (Rudolph, Morrison, & Carroll, 2009). Hence, action-oriented problem solving entails active search, interpretation, and selective decision-making to guide further search. We argue that this approach would be more common among individuals who fall on the explorer side of the continuum of cognitive styles.

The mechanisms behind action-oriented problem solving can be further explained by related concepts within the learning literature. For instance, learning by doing theory assumes that the knowledge people obtain about their choices during active problem solving is the first step of learning (Kolb, 1984). The fundamental idea behind this theory is that by making choices, people gain knowledge of whether their choices lead to the desired outcome (Kolb, 1984). This knowledge is used to modify the next choices in order to increase the likelihood of reaching favorable outcomes and avoiding unfavorable ones (Anzai & Simon, 1979). Similarly, experiential learning theory defines learning as “the process

whereby knowledge is created through the transformation of experience” (Kolb, 1984, p. 41).

Researchers have investigated the possibility of inducing active search during problem solving and its effect on reaching correct solutions to a creative task (Kaufmann & Raaheim, 1973). Kaufmann and Raaheim (1973) found that instructing the experimental group to actively try out different solutions attempts significantly increased their level of activity, compared to the control group. Results also showed that the experimental group, with a greater level of activity, found significantly more correct solutions than the control group. In another study, Burratti and Allwood (2013) found that instructing participants to be active and to try more, did not increase their level of accuracy on confidence judgments measured in the main task. They suggest that a possible explanation for these findings is that participants were given the instructions in a delayed adjustment task, rather than in the main task. In the extra adjustment task, participants’ level of accuracy even decreased, perhaps because there were not any room for improvement left after the first adjustment task (Burratti & Allwood, 2013). By taking these findings into account, we expect that instructing one group to actively explore possible solution alternatives before they begin to work on the problem, will increase their number of actions and attempts.

Furthermore, Kaufmann and Raaheim (1973) suggest that making active attempts at finding alternative solutions during problem solving may be of greater importance in unfamiliar situations than in familiar ones. They argue that while relying on past experience to solve typical problem situations may be effective, seeking new information is necessary for solving unfamiliar problems. According to Kaufmann (1979), a disadvantage of stretching established principles to solve all kinds of problems, is that it might cause the problem solver to overlook simpler alternatives. Exploring alternative solutions through active information search is believed to enable the individual to break with the established boundaries and generate novel solutions (Kaufmann, 1979). Given the unfamiliarity, difficulty, and ill-defined nature of insight problems (Martinsen & Furnham, 2015), we expect that action-oriented problem solving is particularly effective for solving insight problems. This leads us to our first set of hypotheses:

Hypothesis 1a: Action-orientation is more effective for solving the problem than unconscious thought.

Hypothesis 1b: Action-orientation is more effective for solving the problem than analytical thought.

2.2.3 *Unconscious thought*

Studies have investigated the relation between different modes of thought and creativity. The unconscious-thought theory (Dijksterhuis & Nordgren, 2006) distinguishes between conscious and unconscious thought. Conscious thought is the task-relevant thought processes involved when an individual's conscious attention is directed towards the task at hand, while unconscious thought refers to the task-relevant thought processes that occur when attention is on something else (Dijksterhuis & Nordgren, 2006). According to this theory, conscious thought is more convergent, whereas unconscious thought is more divergent (Dijksterhuis & Nordgren, 2006). Divergent thinking is associated with generating novel and creative ideas (Dijksterhuis & Nordgren, 2006). Additionally, it is suggested that conscious thought is more effective when handling simple tasks, while unconscious thought is better for solving complex tasks (Dijksterhuis & Nordgren, 2006).

Researchers have found an explicit connection between creativity, association, and unconscious thought (Zhong, Dijksterhuis, & Galinsky, 2008). According to Kahneman (2011), associative activation is a process in which “ideas that have been evoked trigger many other ideas, in a spreading cascade of activity in your brain” (p. 43). He argues that this process helps bringing memories to mind and reinforcing diverse and compatible ideas quickly. Zhong, Dijksterhuis, and Galinsky (2008) stress that an important characteristic of associative processes is that it seems to be absent during conscious thought. Conscious thought can even undermine the search for creative connections and ideas to solve tasks (Zhong, Dijksterhuis, & Galinsky, 2008). Researchers have found that unconscious thought increased the accessibility to correct solutions to an extremely difficult problem in a Remote Association Test (RAT), and that unconscious thought resulted in more correct answers to RAT problems of moderate difficulty (Zhong, Dijksterhuis, & Galinsky, 2008).

Unconscious thought can be linked to intuition, which is defined as a “gut feeling based on unconscious past experience” (Dijksterhuis & Nordgreen, 2006, p. 105). Intuition often stems from unconscious thought (Dijksterhuis & Nordgreen, 2006), and is also connected to association. Kahneman's (2011) dual process model

describes the intuitive processing approach as system 1 thinking. The core principle behind this system is associative memory, which makes coherent interpretations of what is going on around an individual at any given time (Kahneman, 2011). Intuitive thinking delivers streams, or suggestions, of impressions and feelings (Kahneman, 2011). Some researchers refer to the intuitive processing approach as mindlessness (Pentland & Hærem, 2015). Furthermore, both unconscious thought and intuition are associated with thinking at a fast speed (Yang, Chattopadhyay, Zhang, & Dahl, 2012; Kahneman, 2011). Intuition is believed to produce holistic cognitive associations (Dane, Baer, Pratt, and Oldham, 2011).

Given the connection between unconscious thought, divergent thinking, and associative activation, we argue that an unconscious problem solving approach shares commonalities with an exploratory cognitive style. For instance, both unconscious thought and the explorer strategy are associated with search for novel information, regardless of the problem's complexity. For these reasons, the exploratory cognitive style is likely more effective for insight problems where search constraints are unavailable and the novelty of the task is high (Martinsen, Furnham, & Hærem, 2016).

2.2.4 Analytical thought

In contrast to the fast, associative, and unconscious nature of intuition, the analytical processing approach is linked to slow thinking, concentration, and seizing choices (Kahneman, 2011). Kahneman (2011) refers to the analytical processing approach as system 2 thinking, and argues that its operations are more complex, effortful, deliberate, and orderly compared to system 1 thinking. For these reasons, researchers associate the analytical processing of system 2 with mindfulness (Pentland & Hærem, 2015).

According to Dane, Baer, Pratt, and Oldham (2011), analytical thinking is intended to promote creativity through its systematic thought patterns. However, research evidence supporting the relation between analytical thought and creativity in complex and ill-defined problems, is lacking. Dane, Baer, Pratt, and Oldham (2011) investigated the effect of analytical and intuitive problem solving approaches on creativity and found that neither of the approaches were consistently more effective in increasing creativity than the other. Interestingly, their results showed that utilizing a non-typical problem solving approach that deviated from

participants' typical thinking style resulted in the highest level of creativity (Dane, Baer, Pratt, & Oldham, 2011).

We argue that the analytical problem solving approach is linked to the assimilator cognitive style. Both tend to follow a rational strategy, where the preference is on being efficient, sticking to the familiar, and stretching well-known principles instead of altering them (Kirton, 1976; Kaufmann, 1979). Aforementioned, Kaufmann and Raaheim (1973) argue that this style might not be the most effective when faced with unfamiliar problem situations. By taking into account the unfamiliarity of insight problems and the strong research support for the effect of unconscious thought on creativity, we developed the following hypothesis:

Hypothesis 2: Unconscious thought is more effective for solving the problem than analytical thought.

2.3 Enacted task complexity

Research evidence indicates that complexity is positively related to creativity (Sia & Appu, 2015; Zhou, Hirst, & Shipton, 2012). Researchers have had different interpretations of task complexity. For instance, Wood (1986) argues that all tasks consist of three components: the product, required acts, and information cues. He suggests that the product is the final outcome of behaviors, which can be measured or observed independently of an individual's behavior, and that the required acts and information cues are input components of the task itself. In other words, his perspective ignores the behaviors of the individual solving the task and instead defines task complexity on objective terms. Campbell's (1988) review and analysis classifies the different approaches to task complexity into three distinct categories. These include complexity as a psychological experience, complexity as an interaction between the individual and the task, and complexity in terms of the objective characteristics of the task (Campbell, 1988).

In contrast to Wood's perspective, others suggest that a task is inseparable from the behavior of the individual solving it. As mentioned, Hærem, Pentland, and Miller (2015) argue that an individual's own understanding and enactment of a task defines its level of complexity. They suggest that tasks can be understood as networks consisting of actions performed (referred to as events), and that counting

the number of actions required in a task network can serve as an indicator of its complexity. Their perspective acknowledges that an individual's observable actions must be taken into account in order to fully understand and measure task complexity. In line with this, Chae, Seo, and Lee (2015) suggest that a task's level of complexity depends on how an individual perceives it. Their view also takes into consideration the interaction between the individual and the task, as it emphasizes that people see and understand the same task differently (Chae, Seo, & Lee, 2015). This implies that people can create either a simple or complex task network in their mental representation of the task's problem space.

We believe that the higher the enacted task complexity is, the more opportunities there will be to search for creative solution alternatives. In order to gain a better understanding of the creative process, we seek to investigate the effect of problem solving approaches on enacted task complexity.

Hypothesis 3a: Action-orientation will lead to higher enacted task complexity than unconscious thought.

Hypothesis 3b: Action-orientation will lead to higher enacted task complexity than analytical thought.

2.4 Fixation

Furthermore, fixation has been a topic of interest in research on creative problem solving and insightful thinking. Problem solving requires a mental representation of a task that exemplifies a space of all its possible solutions (Newell & Simon, 1972). According to Segal (2004), the way in which an individual organizes his or her assumptions about a task, that is, the mental representation of the problem space, might be false. He further suggests that being trapped within a false problem space that consists of incorrect assumptions about the task leads to fixation. The more enormous a problem space is, the longer the fixation will endure (Segal, 2004). Newell and Simon (1972) describe fixation as a position of a display that the eyes remain focused on. The forgetting-fixation hypothesis proposes that the correct solution to a task is unattainable because the problem solver wrongly retrieves incorrect solutions (Zhong, Dijksterhuis, & Galinsky, 2008). Fixation keeps individuals from modifying their actions, even when they realize that their

problem solving alternatives are not helpful (Davidson & Sternberg, 1998). Given that analytical thought entails more conscious attention towards the task during problem solving, we suspect that analytical thought will lead to fixation. Therefore, we developed the following hypotheses:

Hypothesis 4a: Analytical thought will lead to more fixation than unconscious thought.

Hypothesis 4b: Analytical thought will lead to more fixation than action-orientation.

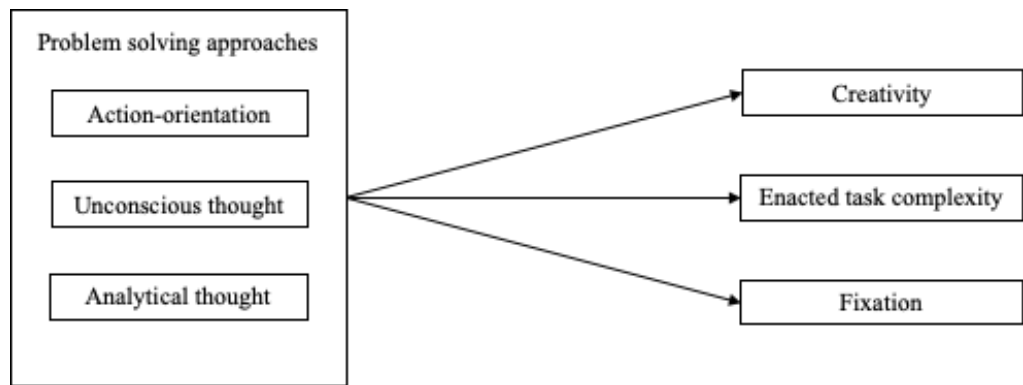


Figure 1. Proposed model of the relation between problem solving approaches and creativity, enacted task complexity, and fixation

2.5 The moderating role of an incubation period

The difficulty of overcoming fixated thinking during problem solving opens up the possibility for an incubation effect (Smith & Blankenship, 1991). An incubation period is intended to give the problem solver a temporary distraction from an unsolved task and sudden insight into the solution upon returning to it (Smith & Blankenship, 1991). The idea behind incubation is that the unconscious continues its activity even when the task is put aside and the conscious attention is directed towards something else for a period of time (Dijksterhuis & Nordgren, 2006). According to Wallas (1926, cited in Isaksen, Dorval, & Treffinger, 2011; Sio & Ormerod, 2009), incubation, where an individual thinks about the problem without being aware of it, is the second phase of creative thought.

Research on the effect of incubation as a means of overcoming fixation and enhancing creativity offer competing findings. In their meta-analytic review, Sio

and Ormerod (2009) generally found that incubation enhances problem solving. However, the incubation effect was weakened when a high cognitive demand task was given during the incubation period (Sio & Ormerod, 2009). Similarly, Baird et al. (2012) found a stronger incubation effect when participants were given an undemanding task rather than a demanding task. The increase in creativity was associated with greater levels of mind wandering (Baird et al. 2012). Contrary to these findings, Olton and Johnson (1976) found no support for an incubation effect in creative problem solving. Given the mechanism behind incubation and hypotheses 4a and 4b, we suspect that participants using an analytical thought approach will benefit the most from the unconscious processes that are argued to occur during an incubation period. We developed the following hypotheses:

Hypothesis 5: The incubation effect on solving the problem will be strongest for analytical thought.

Hypothesis 6: The incubation effect on reducing fixation will be strongest for analytical thought.

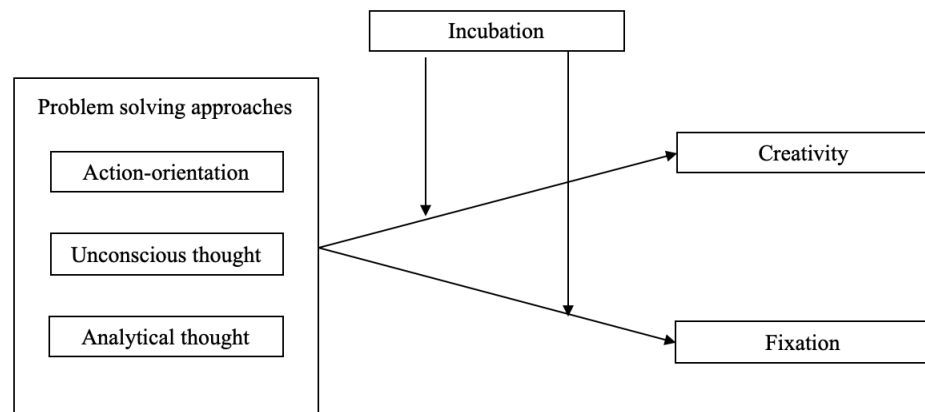


Figure 2. Proposed model of the moderating role of an incubation period in the relation between problem solving approaches, creativity, and fixation

3.0 Method

3.1 Participants

Participants were 129 students (98 females and 31 males) from BI Norwegian Business School. Participants included undergraduate, graduate, and

executive students from HRM, marketing, counseling, and creativity courses who volunteered to participate. The mean age was 29.76 years.

3.2 Procedure

To test our hypotheses, we conducted a randomized experiment. Most of the data were collected in a classroom setting during lecture hours, while some were collected outside the classroom. Participants were first given a brief oral introduction to the experiment and were encouraged to ask questions at all times.

The informed consent form (Appendix 1), the experimental task (Appendix 2), and the A-E inventory (Appendix 3) were administered in booklets in paper format. The experimental task included a cover page with printed instructions and manipulations, and the following four pages contained the nine-dot problem with a total of 24 trials. In addition, these pages included two demographic questions and a question asking whether the participant had solved the task or seen the solution before. This allowed us to control for problem familiarity. Participants were randomly assigned to one of three manipulation treatments by random assignment of booklets. However, randomization of the booklets that included the manipulation instructions was not continuous, as we filled up one condition before proceeding to the next.

After receiving the materials, participants were requested to read the informed consent form and the cover page of the experimental task, before awaiting further information to proceed. Participants were then requested to begin with the nine-dot problem. In the middle of the experiment, participants in all conditions were introduced to an incubation period. They were requested to fill out the A-E Inventory, which was attached as the final page in the booklet. After the incubation period, participants were asked to proceed with the nine-dot problem. Four minutes were given to work on the nine dot-problem both before and after the incubation period, and the incubation period lasted four and a half minutes. In order to avoid time pressure, information regarding time limits was not given. During the experiment, we noted which participants completed the task before the incubation period and which participants completed it after.

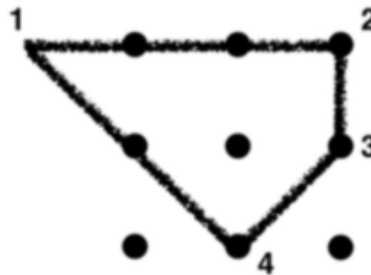
3.3 Measures

3.3.1 Dependent variable: Creativity

For this experiment, the nine-dot problem was employed and participants' results were used as our operational definition of creativity. The nine-dot problem is a well-known insight problem, where the purpose is to draw four lines that connect all the nine dots that are arranged in sets of three rows (MacGregor, Ormerod, & Chronicle, 2001). However, participants are not allowed to lift the pencil or to retrace lines (MacGregor, Ormerod, & Chronicle, 2001). The nine-dot problem is regarded as a difficult and complex insight problem. The solution requires extending the lines beyond the square that is indicated by all the dots (MacGregor, Ormerod, & Chronicle, 2001). According to Chronicle, Ormerod, and MacGregor (2001), studies report that only 0-9.4 percent are able to solve it. However, their experiment found that performance improved slightly in the condition that were presented both a verbal and a visual hint. Adopting the hints given in previous studies (Chronicle, Ormerod & MacGregor, 2001; MacGregor, Ormerod, & Chronicle, 2001), participants in all conditions were given the following instructions, including one written and one verbal hint:

The figures on the following pages contain nine dots arranged in three rows. Your task is to draw four straight lines that go through the middle of all the nine dots, without lifting the pencil or retracing a line. You can start from any position. Hint: Extending some of the lines beyond the dots is critical to solve the problem.

Please mark your starting position with "1". Every time you change the direction of a line, mark the beginning of the new line with the next number. See example below for illustration



3.3.2 *Dependent variable: Enacted task complexity*

To measure enacted task complexity, we created a library of actions (Appendix 5) that represents the possible paths that a participant can follow when solving the nine-dot problem. Our measurement of enacted task complexity was grounded in Hansson's (2018) dissertation, where enacted task complexity is represented as a function of nodes and the links between them (Hansson, 2018). Hansson (2018) states that different enactments result in more or less complex pattern of actions. His measurement of enacted task complexity takes into account both the number of paths and the unique links between the actions participants managed to create in the nine-dot problem.

3.3.3 *Dependent variable: Fixation*

The measurement of fixation was based on Hansson's (2018) work. Having the library of actions to represent the different possible paths in the nine-dot problem, fixation was measured as the percentage of actions that fit the patterns in the library of actions. Hansson's (2018, p. 65) following formula for routinization was used to calculate fixation:

$$RT = \frac{\sum_{i=1}^s (n_i * length_i)}{nActions}$$

3.3.4 *Independent variable: Problem solving approaches*

In addition to the nine-dot problem instructions given to all participants, a new set of instructions were given in order to manipulate our independent variable. The new instructions, inspired from previous researchers (Dane, Praer, Pratt, & Oldham, 2011), were the following:

Condition 1: Analytical thought. *Please think carefully about the best way to represent the problem before trying any solution attempts. Remember that the best way to solve such tasks is by thinking thoroughly through the solutions before drawing them.*

Condition 2: Unconscious thought. *Please try to rely on your gut feeling when trying to find the solution of this task. Remember that unconscious thought is the most effective when solving this task.*

Condition 3: Action-oriented problem-solving. *We are interested in investigating the effect of being active while trying to find the solution of this task. Please work actively to explore possible solutions. Remember that the most effective information search is done by drawing new lines and thereby exploring new solution alternatives.*

3.3.5 Moderating variable: Incubation period

In order to investigate the incubation effect as a potential moderator in the relation between problem solving approaches and creativity and between problem solving approaches and fixation, all participants were given an incubation period of four and a half minutes. This enabled us to test a potential incubation effect between groups. Participants were requested to fill out the Assimilator-Explorer (A-E) Inventory during this period.

3.3.6 Control variable: A-E Inventory

The revised A-E inventory (Kaufmann & Martinsen, 1992) was used to control for individual differences in cognitive style. The inventory contains 30 items and four lie indicators. Each item is scored on a 5-point Likert scale. The scale is continuous, where assimilators have lower total scores and explorers have higher total scores (Martinsen & Diseth, 2011). Two sample items are: “I prefer situations in which you have to work according to specific rules” (reversed scoring) and “I prefer to figure things out on my own when I am learning something new”.

4.0 Results

4.1 Data treatment and analysis

To calculate the descriptives, correlations, and the one-way ANOVAs, we used the data set that included all 129 participants. To test our hypotheses, we ran both logistic regression and multiple linear regression analyses. To analyze the effects of the incubation period, we included the attempts performed both before

and after the incubation. Thus, all participants were included twice, in a repeated-measure design, except those that solved the problem before the incubation. This repeated measure allowed us to analyze the effect of incubation across groups.

4.2 Manipulation check

		ANOVA			
Table 1. Manipulation Check		Mean	SD	F	Sig.
Total Attempts	Between Groups			1.42	0.25
	Analytical	6.02	5.04		
	Unconscious	7.14	5.66		
	Action-oriented	5.33	4.33		
Total Actions	Total	6.16	5.05		
	Between Groups			1.51	0.23
	Analytical	45.44	35.89		
	Unconscious	54.56	40.04		
	Action-oriented	41.49	30.88		
	Total	47.16	35.94		

For testing the effect of our manipulation instructions, we conducted a one-way ANOVA. Table 1 shows that the unconscious thought condition had a higher mean in both total attempts and total actions, followed by the analytical thought condition. However, there is no statistically significant difference in total attempts ($p > .10$) or total actions ($p > .10$) between the groups. Thus, our manipulation instructions were not effective in terms of inducing activity.

4.3 Descriptive statistics

Table 2. Descriptive Statistics and Correlations

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
1. Analytical	.33	.47	-											
2. Unconscious	.33	.47	-.50***	-										
3. Action-O.	.33	.47	-.50***	-.50***	-									
4. Age	29.76	9.47	-.31***	-.28***	.59***	-								
5. Gender	.24	.43	.10	-.05	-.05	-.14	-							
6. A-E score	88.16	13.28	-.03	-.14	.17*	.22**	.20**	-						
7. Time of Completion	1.28	.81	.02	-.18**	.16*	.72*	-.15*	-.09	-					
8. Total Attempts	6.16	4.05	-.02	.14	-.12	-.11	-.09	-.11	.43***	-				
9. Total Actions	47.16	35.94	-.03	.15*	-.11	-.10	-.12	-.12	.39***	.97***	-			
10. Result	.50	.50	.02	.15*	-.18**	-.23***	.10	.01	-.90***	-.34***	-.29***	-		
11. Fixation	.25	.26	.50***	-.27***	-.23***	-.11	-.11	-.14	.15*	.26***	.24***	-.10	-	
12. ETC	123.42	462.67	.05	.01	-.06	-.12	.05	.05	.09	.64***	.64***	-.02	.13	-

Note. N = 129

*** p < .01

** p < .05.

* p < .1

Before testing our hypotheses, the relations between our variables were reviewed. Table 2 shows the means, standard deviations, and the correlations between our variables. As seen in the table, there is a strong negative correlation between analytical thought and age ($r = -.31, p < .01$) and a strong positive correlation between analytical thought and fixation ($r = .50, p < .01$). This indicates that participants in the analytical thought condition are younger and fixate more. The table also shows a strong negative correlation between unconscious thought and age ($r = -.28, p < .01$) and between unconscious thought and fixation ($r = -.27, p < .01$). This implies that participants in the unconscious thought condition are younger and fixate less. Furthermore, there is a strong positive correlation between the action-oriented condition and age ($r = .59, p < .01$) and a strong negative correlation between the action-oriented condition and fixation ($r = -.23, p < .01$). This indicates that participants in the action-oriented condition are of higher age and fixate less. Due to the strong correlations between age and groups, the variable age will be treated with caution. There is a strong negative correlation between age and result ($r = -.23, p < .01$), which means that younger participants solved the task more frequently than participants of higher age. The table also shows a strong positive correlation at the .01 level between time of completion and total attempts ($r = .43$) and between time of completion and total actions ($r = .39$). This indicates that participants who did not solve the problem completed more attempts and actions. As seen in the table, there is a strong negative correlation between time of completion and result ($r = -.90, p < .01$). As expected, total attempts have a strong positive correlation at the .01 level with total actions ($r = .97$), fixation ($r = .26$), and enacted task complexity (ETC) ($r = .64$). There is a strong negative correlation between total attempts and result ($r = -.34, p < .01$), which means that the more attempts participants completed, the less likely they were to solve the problem. The table also shows that total actions have strong positive correlations with fixation ($r = .24, p < .01$) and with ETC ($r = .64, p < .01$). This means that a greater number of actions leads to more fixation and higher enacted task complexity. There is a strong negative correlation between total actions and result ($r = -.29, p < .01$), which implies that the more actions participants completed, the less likely they were to solve the problem.

Moreover, there is a moderately strong negative correlation between unconscious thought and time of completion ($r = -.18, p < .05$), which indicates that participants in the unconscious thought condition solved the problem more often

prior to the incubation period. As seen in the table, there is a moderately strong negative correlation between action-orientation and result ($r = -.18, p < .05$). This implies that participants in the action-oriented problem solving condition solved the problem less frequently. There is a moderately strong positive correlation between age and A-E score ($r = .22, p < .05$), which implies that older participants lean towards the exploratory end of the A-E cognitive styles continuum. There is also a moderately strong positive correlation between A-E score and gender ($r = .20, p < .05$). This means that males are more exploratory than females.

The table also shows a positive correlation between unconscious thought and total actions ($r = .15, p < .1$) and between unconscious thought and result ($r = .15, p < .1$), though at marginal significance levels. There are also marginally positive correlations between action-orientation and A-E score ($r = .17, p < .1$) and between action-orientation and time of completion ($r = .16, p < .1$). There is also a marginal positive correlation between age and time of completion ($r = .72, p < .1$) and between fixation and time of completion ($r = .15, p < .1$). There is a marginally significant negative correlation between gender and time of completion ($r = -.15, p < .1$).

ANOVA				
Table 3. Comparison between groups				
		Mean	SD	Sig.
Result	Between Groups			0.10
	Total	0.50	0.50	
ETC	Between Groups			0.78
	Total	123.42	462.67	
Fixation	Between Groups			0.00
	Total	0.25	0.26	

Furthermore, we conducted a one-way ANOVA to compare results, fixation, and enacted task complexity between groups. As seen in table 3, there is a significant difference in fixation between groups ($p < .01$). Results between groups are different at marginal significance at the .1 level. However, there is not a statistically significant difference between groups in terms of enacted task complexity.

4.4 Hypotheses testing

For testing our hypotheses, we conducted both logistic regression and multiple linear regression analyses. Due to the strong positive correlation between total actions and total attempts ($r = .97$) and the unexpected strong correlation between age and groups ($r = -.31$, $r = -.28$, $r = .59$), we excluded both total actions and age as predictor variables in the remaining analyses (see table 2). We hypothesized that action-orientation is more effective for solving the problem than unconscious thought (hypothesis 1a) and analytical thought (hypothesis 1b). We also hypothesized that unconscious thought is more effective for solving the problem than analytical thought (hypothesis 2). To test these hypotheses, we conducted a logistic regression analysis with result as our dependent variable.

Table 4. Summary of Logistic Regression Analysis

Variables	Model 1	Model 2	Model 3
	β	β	β
Constant	1.85	.76	.75
Gender	.25	.17	.17
A-E score	-.01	-.01	-.01
Incubation_std	-.51*	-.47	-.47
Total Attempts	-.12***	-.15***	-.15***
Analytical_std		.73**	.73**
Unconscious_std		1.22***	1.22***
Analytical_std * Incubation_std			.03
Unconscious_std * Incubation_std			-.02
Nagelkerke R Square	.13	.19	.19

*** $p < .01$ ** $p < .05$ * $p < .1$

Dependent variable: Result

As seen in table 4, model 1 includes all the control variables, model 2 includes all the control variables and the dummy variables that represent the three group conditions, and model 3 includes all the variables in model 2 as well as the interaction effects between groups and incubation. Table 4 shows that both model 2 and model 3 have a Nagelkerke R-square of .19. This indicates that 19 percent of the variability in result is explained by the predictor variables included in the models. Furthermore, it implies that adding the interactions effects does not improve the model. As seen in the table, the predictors total attempts ($\beta = -.15$, $p < .01$), analytical ($\beta = .73$, $p < .05$), and unconscious ($\beta = 1.22$, $p < .01$) are significant contributors to the prediction of results. These findings indicate that unconscious thought is a significantly better predictor of result than both action-orientation and analytical thought. Results also show that analytical thought is a significantly stronger predictor of result than action-orientation. Hence, action-orientation is the

weakest predictor of results, and hypothesis 1a and hypothesis 1b are therefore not supported. Hypothesis 2 is supported.

Table 5. Summary of Linear Regression Analysis

Variable	Model 1 β	Model 2 β	Model 3 β
Gender	.09*	.09*	.09*
A-E score	.11**	.10*	.10*
Incubation_std	-.03	-.04***	-.04***
Total Attempts	.66***	.68***	.68***
Analytical_std		.03	.03
Unconscious_std		-.06	-.06
Analytical_std * Incubation_std			.01
Unconscious_std * Incubation_std			-.02
Adjusted R ²	.43	.43	.43

*** p < .01 ** p < .05 * p < .1

Dependent variable: ETC

Hypothesis 3a and 3b state that action-orientation will lead to higher enacted task complexity (ETC) than unconscious thought and analytical thought respectively. We conducted multiple linear regression analyses to test these hypotheses with ETC as our dependent variable. As seen in table 5, the three models have the same R-square of .43. Neither analytical ($\beta = .04, p > .1$) nor unconscious ($\beta = -.06, p > .1$) are significant predictor variables of ETC. This implies that neither of the problem solving conditions contribute significantly more than the others in explaining ETC. Therefore, hypothesis 3a and hypothesis 3b are not supported.

Table 6. Summary of Linear Regression Analysis

Variables	Model 1 β	Model 2 β	Model 3 β
Gender	-.04	-.09*	-.09*
A-E score	-.14**	-.12**	-.12**
Incubation_std	.01	-.01	.01
Total Attempts	.23***	.26***	.26***
Analytical_std		.45***	.45***
Unconscious_std		-.09	-.09
Analytical_std * Incubation_std			-.02
Unconscious_std * Incubation_std			.01
Adjusted R ²	.07	.31	.30

*** p < .01 ** p < .05 * p < .1

Dependent Variable: Fixation

We hypothesized that analytical thought will lead to more fixation than unconscious thought (hypothesis 4a) and action-orientation (hypothesis 4b). Table 6 provides a summary of multiple linear regression analysis with fixation as our dependent variable. As seen in the table, the adjusted R-square decreases slightly

from .31 in model 2 to .30 in model 3. The minimal change suggests that including interactions effects in the model does not contribute in explaining fixation. However, by including all the predictor variables in model 3, we see that analytical is a significant predictor of fixation ($\beta = .45, p < .01$). In other words, the analytical thought condition leads to significantly more fixation than both the action-orientation condition and the unconscious thought condition. Hence, hypothesis 4a and 4b are supported. Table 6 also shows that the variable total attempts ($\beta = .26$) predicts fixation at the .01 significance level. This finding indicates that the more attempts participants performed, the more fixated they became. Furthermore, A-E score ($\beta = -.12, p < .05$) is a moderately strong positive predictor of result, which implies that participants at the assimilator side of the continuum fixated more than participants that lean towards the explorer side.

Hypothesis 5 presumes that the incubation effect on solving the problem will be strongest for analytical thought. As seen in table 4, there are no significant interaction effects between analytical thought and incubation ($\beta = .03, p > .1$) or between unconscious thought and incubation ($\beta = -.02, p > .1$) on result. This indicates that incubation is not a significant predictor of results in any of the groups. Hypothesis 5 is therefore not supported.

Our last hypothesis states that the incubation effect on reducing fixation will be strongest for analytical thought. Table 6 shows that neither the interaction effect between analytical thought and incubation ($\beta = -.02, p > .1$) nor between unconscious thought and incubation ($\beta = .01, p > .1$) are significant contributors of fixation. These findings do not support hypothesis 6.

5.0 Discussion

The purpose of this thesis was to explore how problem solving approaches facilitate both the creative process and the creative outcome. In particular, we aimed to investigate how three distinct problem solving approaches impact creativity, enacted task complexity, and fixation. The role of an incubation period was also investigated as a potential moderator of the relationship between problem solving approaches and creativity and between problem solving approaches and fixation.

In order to manipulate problem solving approaches, participants received manipulation instructions that were intended to induce the desired activity. Contrary to previous research findings (Kaufmann & Raaheim, 1973), manipulation instructions were ineffective when number of actions and attempts were accounted

for. However, the insignificant difference in activity between groups may be due to the small sample size.

Our first set of hypotheses predicted that action-orientation would outperform both unconscious thought and analytical thought in solving the nine-dot problem. These hypotheses were built upon an extension of existing theoretical frameworks (Rudolph, Morrison, & Carroll, 2009; Anzai & Simon, 1979) and research findings (Kaufmann & Raaheim, 1973; Kaufmann, 1979), which suggest that active search through an explorer strategy is best suited for ill-defined and complex problems. However, we mentioned earlier that no studies have compared the effect of action-oriented problem solving, unconscious thought, and analytical thought in a single experiment. Our results did not support these hypotheses. In fact, our results indicated that action-orientation was the least effective out of the three problem solving approaches, in terms of finding the correct solution. As already mentioned, Rudolph, Morrison, and Carroll (2009) suggest that problem solving is an adaptive process. Their framework proposes that taking action leads to new cues that become available for interpretation, and that the evaluation of these cues are used to guide further search in order to reach the desired goal. In other words, an important part of the action-oriented problem solving process is to make sense of the flow of information generated through actions and to use this knowledge to reassess initial choices (Rudolph, Morrison, & Carroll, 2009). A possible explanation for our findings may be that participants were unable to assign enough time to make sense and learn from their previous attempts. Perhaps, the limited time assigned to solving the nine-dot problem interfered with the adaptive process of action-oriented problem solving, which consequently resulted in poorer performance than anticipated.

Hypothesis 2 predicted that unconscious thought would be more effective for solving the nine-dot problem than analytical thought. We based this hypothesis on theory and research (Dijksterhuis & Nordgreen, 2006; Zhong, Dijksterhuis, & Galinsky, 2008) that have found a positive relation between unconscious processing and creativity. Our results indicate that unconscious thought was superior to both action-orientation and analytical thought. Hence, our findings supported hypothesis 2. These results suggest that the unconscious thought processes that occur when attention is directed somewhere other than the task at hand, increase creativity to a greater extent than both active exploration (action-orientation) and a careful and thorough approach (analytical thought).

In order to control for individual differences in cognitive style, participants were requested to fill out the A-E Inventory during the incubation period. Building on previous research (Kaufmann, 1979; Kaufmann & Raaheim, 1979; Martinsen & Furnham; 2015), we predicted that explorers would perform better than assimilators on the nine-dot problem, given the problem's difficulty. However, our results show that there was no significant difference between assimilators and explorers in terms of performance. This might be attributable to our small sample size.

We expected that action-orientated problem solving would lead to a greater level of enacted task complexity compared to both unconscious thought and analytical thought. Results did not support these hypotheses, as neither of the problem solving approaches were found to be significant predictors of enacted task complexity. A possible explanation for this finding may be related to the ineffectiveness of our manipulation instructions. As mentioned above, enacted task complexity is a measure of different actions and the links between them. In other words, complexity increases as both the number and uniqueness of actions and links increase. Since there were no significant differences in number of actions or attempts between groups, it is not surprising that the groups did not differ in terms of enacted task complexity. However, our results showed that participants identified on the explorer side of the A-E continuum created a greater level of enacted task complexity than those on the assimilator side. This leads us to believe that it is possible that our findings would be different if manipulation instructions were successful in producing significant differences in activity between groups.

Davidson and Sternberg (1998) propose that fixation prevents people from modifying their actions even when they are aware that their problem solving alternatives do not represent progression towards the desired outcome. Because analytical thought involves conscious attention towards the mental representation of a task's problem space, we predicted that participants in the analytical thought condition would become the most fixated out of the three groups. Consistent with theory, our findings supported this hypothesis. Furthermore, we argued that assimilators tend to rely on analytical and rational thought. Based on this, we anticipated that assimilators would fixate more than explorers. Results supported this prediction as well, as assimilators were found to fixate more than explorers.

Building on the previous prediction, we hypothesized that the incubation effect on solving the nine-dot problem and on reducing fixation, would be the strongest for the analytical thought condition. This hypothesis was grounded in the

idea that during a break, the unconscious continues its processing activity, even when the conscious attention is directed on something other than the problem (Dijksterhuis & Nordgreen, 2006; Smith & Blankenship, 1991). We decided to request participants to complete the A-E Inventory during the incubation period. This decision was based on Baird et al. (2012) and Sio and Ormerod's (2009) research, which found that the incubation effect was strongest when an undemanding task, such as reading, was performed in the incubation period. As already mentioned, research on the incubation effect has offered competing findings. While some studies have reported a strong incubation effect, others have not found support for any effect. Our results did not find significant support for the incubation effect in terms of reducing fixation or solving the nine-dot problem. Even though our findings are in agreement with those of previous researchers (Olton & Johnson, 1976), it is worth considering an alternative explanation for the ineffectiveness of incubation in this experiment. Given the relatively low level of control during data collection, it may be possible that distraction from the nine-dot problem was ineffective because participants were already distracted by noise.

6.0 Limitations and future research directions

There are several limitations to the present study. Some considerations should be taken with regard to the sample used. Our sample size was relatively small and consisted of students enrolled in courses at a business school. However, the intention of the study was not to produce highly generalizable findings, but instead to serve as an initial study to test the theorized hypotheses. Another consideration to take into account is the ineffectiveness of our manipulation instructions. Even though the instructions used to manipulate the independent variable built on findings and suggestions from previous researchers (Dane, Praer, Pratt, & Oldham, 2011; Kaufmann & Raaheim, 1973), no significant differences were found between groups when number of actions and attempts were accounted for. The ineffectiveness of our manipulations may be attributable to our small sample size. Future researchers may use a larger and more heterogeneous sample in order to increase the generalizability of findings and to assess the effectiveness of manipulation instructions.

Another limitation in the present study is the way in which the incubation period was introduced. Ideally, we would have six experimental groups instead of three, in order to investigate the moderating role of an incubation period both

between and within groups. Due to limitations in our sample size, we were not able to explore the effect of incubation within the three groups. Although no significant effects of incubation were found between groups in terms of reducing fixation or finding the solution, future research may look into whether an incubation period creates significant differences among participants within groups.

Limitations were also noted during data collection. Since most of the data was collected during lecture hours, participants received four and a half minutes to complete the A-E Inventory in the incubation period, prior to returning to the nine-dot problem for four additional minutes. We observed that some participants were unable to finish the A-E Inventory within this time frame, and therefore used part of the time assigned to the nine-dot problem on finishing the questionnaire. In other words, not all participants ended up with the same amount of time dedicated to the nine-dot problem. Another limitation to the present study is the low level of control we were able to exercise during data collection. We were two researchers present in classes up to 40 participants. Consequently, it was challenging to keep the classes quiet at all times during the experiment. Furthermore, as some of the data were collected outside the classroom setting, noise may have influenced participants' concentration and thereby performance on the nine-dot problem. Future researchers may consider collecting data with fewer participants present at once and in a laboratory setting where environmental factors do not interfere with their concentration.

Another point of consideration is that 19 out of 64 participants across all groups solved the nine-dot problem on their first trial. As research has found that few people are able to solve it even when presented with hints (Chronicle, Ormerod & MacGregor, 2001), we find it suspicious that 19 participants found the solution on their first attempt. However, we checked for problem familiarity, and since these participants reported that they had not solved the task or seen the solution before, we decided to include them in our data. Potentially, the low level of control during data collection may have been a contributing factor to this issue. Since some participants sat relatively close due to the large classroom sizes, talking between participants may have resulted in some participants solving the problem on their first trial. We suggest that future researchers design studies that account for this risk by exercising more control.

Also worth mentioning is that random assignment of manipulation instructions was insufficient in taking care of an equal distribution of age between

groups. Because we filled up one group at a time and were unaware that one of the classes from which we collected data included executive students and one of the classes included undergraduate students, age correlated significantly with the groups. As illustrated in the descriptive statistics, participants in the action-oriented problem solving conditions were of significantly higher age than participants in the two other conditions. Therefore, we did not account for age in the data analyses. A better way to randomize would be to assign participants to conditions on a continuous basis. However, it might be useful to consider whether age could be an alternative explanation in results, if included in the analyses. For instance, a point of consideration is whether people of higher age would be more creative due to differences in professional experience. Even though the high correlation between age and group is the result of our unfortunate group distribution, we recommend future researchers to investigate the alternative explanations associated with age.

Lastly, it is worth mentioning that although insight problems are often seen in experimental psychology (Hélie & Sun, 2010) and creativity research, some argue that the predictive validity of insight problems to real-world creativity needs to be considered carefully (Beatty, Nusbaum, & Silvia, 2014).

7.0 Conclusion

Recent organizational landscape indicates a continuous shift from driving operational excellence towards a requirement to solve more ill-defined and complex tasks. Since such problems usually lack structure, creativity plays an increasing role in solving these problems effectively. While research literature on creativity has increased, there are still considerable shortcomings in our understanding of the dynamics that lead to and derive from different problem solving approaches. This thesis has looked into three distinct problem solving approaches, namely action-orientation, analytical thought, and unconscious thought, to examine their effects on individuals' abilities to solve insight problems, which was represented by the nine-dot problem. Furthermore, the investigation of the effect of these problem solving approaches on enacted task complexity and fixation aimed to explore areas in the creative process that theory and research have failed to explain consistently.

While the data collected for this study indicated that the manipulation instruction individuals received did impact their ability to solve the problem, we were only able to confirm that the unconscious thought group outperformed both the analytical thought group and the action-oriented group. Results also showed that

the analytical thought group performed better than the action-oriented group. Furthermore, in accordance with David and Sternberg's (1998) proposal, we were able to confirm that individuals who received the analytical thought manipulation instruction got more fixated than the other groups, indicating that an incorrect mental representation of the task's problem space limited participants' ability to use cues to cultivate new problem solutions. In line with that, participants who scored low on the A-E Inventory (assimilators) overall tended to get more fixated than participants on the explorer side. With regard to the incubation effect, we did not find significant differences across groups. Neither did our study indicate any significant predictors with regard to enacted task complexity, which may well be attributed to the lack of evidence that our manipulation instructions significantly impacted total attempts or total actions.

This study aimed to investigate a rather unexplored field within creativity literature, in order to identify theoretical and practical implications, as well as lead to recommendations with regard to further research. This thesis contributes to the creativity literature with increased knowledge of the potential antecedents and inhibitors of the creative process and the creative outcome. Furthermore, our study contributes by combining three problem solving approaches into a single research, enabling comparison among them. The insights this study obtained may help organizations to foster creativity as a means to facilitate organizational success by enabling innovation, which today is considered one of the most important drivers of success. A promising area for further research to improve the creative capacity of employees, is the investigation of the effect of incubation within the three problem solving approaches.

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9.0 Appendices

9.1 Appendix 1: Informed consent form

Master Thesis Experiment

Information about the experiment

In this study, we will ask you to take part in an experiment for our master thesis. The purpose of this experiment is to investigate the role of enacted task complexity and different problem-solving approaches on creativity. You will be asked to complete an insight problem and a survey. Together with data from the experimental task, the survey will provide the researchers with more detailed insight into the research question. After the session, you may stay to receive a debrief where the experiment will be linked to corresponding theory and literature.

Confidentiality: The data collected in this experiment will be anonymous and handled in accordance to best practice. Please do not write any identifying personal information on the experimental task or the survey.

Participation is strictly voluntary, and you may withdraw from the experiment at any time. If you for any reason wish to withdraw, please inform one of the experimenters and the study will end. You can also request that the data will not be used for research.

If you have any questions regarding the study, you can contact: Karime Moedano, email: *karimoedano@gmail.com*, or Camelia Gharakhanloo, email: *camelia.gha@gmail.com*.

The experiment will take approximately 20 minutes.

Thank you for your participation!

Please indicate below whether you understand your rights and agree to participate in the experiment.

Yes: _____

No: _____

Date: _____

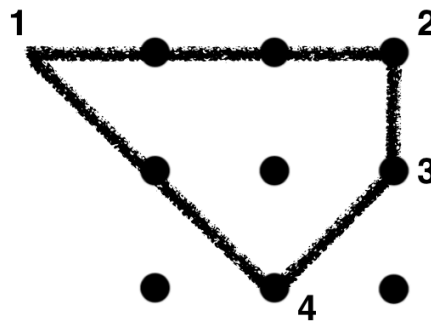
9.2 Appendix 2: Nine-dot problem

9.2.1 Action-orientation manipulation

Nine-dot Problem

The figures on the following pages contain nine dots arranged in three rows. Your task is to draw four straight lines that go through the middle of all the nine dots, without lifting the pencil off the paper or retracing a line. You can start from any position. *Hint:* Extending some of the lines beyond the dots is critical to solve the problem.

Please mark your starting position with “1”. Every time you change the direction of a line, mark the beginning of the new line with the next number. See example below for illustration.



We are interested in investigating the effect of being active while trying to find the solution of this task. Please work actively to explore possible solutions. Remember that the most effective information search is done by drawing new lines and thereby exploring new solution alternatives.

Please answer the following questions before proceeding to the task:

Age: _____

Gender: Female _____, Male _____

Have you solved the task or seen the solution before? Yes _____, No _____

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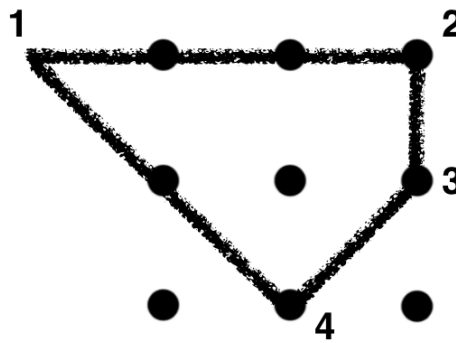
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9.2.2 Unconscious thought manipulation

Nine-dot Problem

The figures on the following pages contain nine dots arranged in three rows. Your task is to draw four straight lines that go through the middle of all the nine dots, without lifting the pencil off the paper or retracing a line. You can start from any position. *Hint:* Extending some of the lines beyond the dots is critical to solve the problem.

Please mark your starting position with “1”. Every time you change the direction of a line, mark the beginning of the new line with the next number. See example below for illustration.



Please try to rely on your gut feeling when trying to find the solution of this task. Remember that unconscious thought is the most effective when solving this task.

Please answer the following questions before proceeding to the task:

Age: _____

Gender: Female _____, Male _____

Have you solved the task or seen the solution before? Yes _____, No _____

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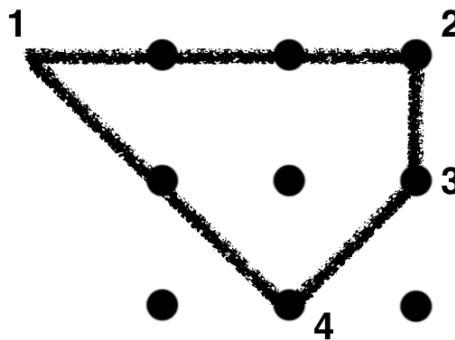
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9.2.3 Analytical thought manipulation

Nine-dot Problem

The figures on the following pages contain nine dots arranged in three rows. Your task is to draw four straight lines that go through the middle of all the nine dots, without lifting the pencil off the paper or retracing a line. You can start from any position. *Hint:* Extending some of the lines beyond the dots is critical to solve the problem.

Please mark your starting position with “1”. Every time you change the direction of a line, mark the beginning of the new line with the next number. See example below for illustration.



Please think carefully about the best way to represent the problem before trying any solution attempts. Remember that the best way to solve such tasks is by thinking thoroughly through the solutions before drawing them.

Please answer the following questions before proceeding to the task:

Age: _____

Gender: Female _____, Male _____

Have you solved the task or seen the solution before? Yes _____, No _____

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9.3 Appendix 3: A-E Inventory



Furthermore, people often prefer different types of work, tasks or situations. In answering the questions below, try to imagine how you usually act when you solve problems at work, school, etc. Also decide which types of situations you like best. You are asked to determine whether each of the following statements MOST TYPICALLY or USUALLY describes your approach to problem solving, or which types of situations you usually like best. Cross out the dot in the column which best describes you, and use the 'neutral' answer only if you feel you must. Please make one mark per statement, and please answer all questions. There are no 'right' or 'wrong' answers. This is not a test of intelligence or aptitude.

INSTRUCTIONS

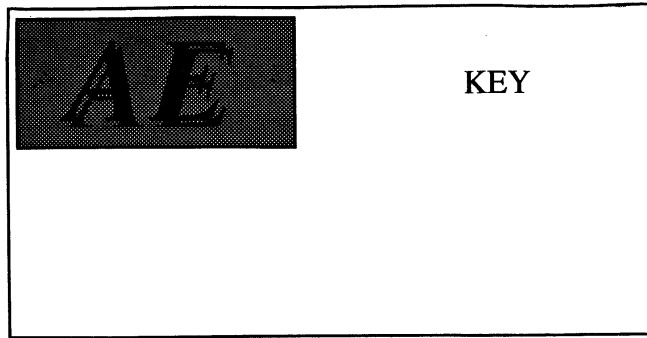
We all have different ways of solving problems, whether they are at work, school or in our spare time. Some people tend to stick to one particular way of solving problems, others stick to a different way, and some people are more likely to combine or vary between different approaches.

Name _____
 Age _____
 Gender _____
 Occupation _____
 Education _____

	Very poor description	Poor description	Neutral	Good description	Very good description
1. I never get angry if I get stuck.
2. I prefer detailed work which requires neatness and precision.
3. I prefer situations in which you have to stick to options that are tried and true.
4. I like best to work without a prearranged plan.
5. I often try things out without planning systematically.
6. I always answer honestly.
7. I prefer to stick to what I know well.
8. When trying to solve a problem, I most often try to find new means of doing so.
9. I prefer working without any clear guidelines.
10. I quite like situations in which it is necessary to break with conventional wisdom.
11. I prefer to avoid major changes.
12. I work best in situations which are clear and straightforward.
13. I prefer situations in which you have to work according to specific rules.
14. I prefer to figure things out on my own when I am learning something new.
15. I have never made a major error in solving a problem.
16. I prefer to plan and structure what I am to do.
17. I am best suited for work which requires precision and a systematic approach.
18. I most often adopt a playful and curious approach to my work.
19. I prefer to improvise in what I do.
20. I prefer work with set routines.
21. I bubble with ideas when I am solving problems.
22. I most like situations in which you have to violate established norms.
23. I most like to work with things I don't know too well from before.
24. I prefer to have clear guidelines to stick to in work.
25. I prefer to have systematic instruction when learning something new.
26. I have never cheated.
27. I am exceptionally precise and task-oriented in my work.
28. I like situations in which you have to seek new knowledge actively.
29. I mostly stick to accepted ideas.
30. I work best in complex situations.
31. I prefer to stick to a set plan when working or solving problems.
32. I can change my opinions/ideas even if the situation does not require it.
33. I most often try to use well-tried methods for solving problems.
34. I most like to investigate uncharted territory.

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9.4 Appendix 4: A-E key



	Very poor description	Poor description	Neutral	Good description	Very good description
1. I never get angry if I get stuck.	Distractor/Lie indicator				
2. I prefer detailed work which requires neatness and precision.	5.....	4.....	3.....	2.....	1
3. I prefer situations in which you have to stick to options that are tried and true.	5.....	4.....	3.....	2.....	1
4. I like best to work without a prearranged plan.	1.....	2.....	3.....	4.....	5
5. I often try things out without planning systematically.	1.....	2.....	3.....	4.....	5
6. I always answer honestly.	Distractor/Lie indicator				
7. I prefer to stick to what I know well.	5.....	4.....	3.....	2.....	1
8. When trying to solve a problem, I most often try to find new means of doing so.	1.....	2.....	3.....	4.....	5
9. I prefer working without any clear guidelines.	1.....	2.....	3.....	4.....	5
10. I quite like situations in which it is necessary to break with conventional wisdom.	1.....	2.....	3.....	4.....	5
11. I prefer to avoid major changes.	5.....	4.....	3.....	2.....	1
12. I work best in situations which are clear and straightforward.	5.....	4.....	3.....	2.....	1
13. I prefer situations in which you have to work according to specific rules.	5.....	4.....	3.....	2.....	1
14. I prefer to figure things out on my own when I am learning something new.	1.....	2.....	3.....	4.....	5
15. I have never made a major error in solving a problem.	Distractor/Lie indicator				
16. I prefer to plan and structure what I am to do.	5.....	4.....	3.....	2.....	1
17. I am best suited for work which requires precision and a systematic approach.	5.....	4.....	3.....	2.....	1
18. I most often adopt a playful and curious approach to my work.	1.....	2.....	3.....	4.....	5
19. I prefer to improvise in what I do.	1.....	2.....	3.....	4.....	5
20. I prefer work with set routines.	5.....	4.....	3.....	2.....	1
21. I bubble with ideas when I am solving problems.	1.....	2.....	3.....	4.....	5
22. I most like situations in which you have to violate established norms.	1.....	2.....	3.....	4.....	5
23. I most like to work with things I don't know too well from before.	1.....	2.....	3.....	4.....	5
24. I prefer to have clear guidelines to stick to in work.	5.....	4.....	3.....	2.....	1
25. I prefer to have systematic instruction when learning something new.	5.....	4.....	3.....	2.....	1
26. I have never cheated.	Distractor/Lie indicator				
27. I am exceptionally precise and task-oriented in my work.	5.....	4.....	3.....	2.....	1
28. I like situations in which you have to seek new knowledge actively.	1.....	2.....	3.....	4.....	5
29. I mostly stick to accepted ideas.	5.....	4.....	3.....	2.....	1
30. I work best in complex situations.	1.....	2.....	3.....	4.....	5
31. I prefer to stick to a set plan when working or solving problems.	5.....	4.....	3.....	2.....	1
32. I can change my opinions/ideas even if the situation does not require it.	1.....	2.....	3.....	4.....	5
33. I most often try to use well-tried methods for solving problems.	5.....	4.....	3.....	2.....	1
34. I most like to investigate uncharted territory.	1.....	2.....	3.....	4.....	5

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9.5 Appendix 5: Library of actions

