THE ROLE OF EXPERTISE IN DESIGN FIXATION: MANAGERIAL IMPLICATIONS FOR CREATIVE LEADERSHIP

Anaëlle Camarda
CNRS Unit 8240, Laboratory for the Psychology of Child Development and Education, Paris Descartes University, 46 rue Saint Jacques, 75005, Paris, France,
anaelle.camarda@parisdescartes.fr
Hicham Ezzat
Center for Management Science, Chair TMCI, Mines ParisTech, 60 boulevard Saint Michel, 75006, Paris, France,
hichamezzat@gmail.com
Mathieu Cassotti
CNRS Unit 8240, Laboratory for the Psychology of Child Development and Education, Paris Descartes University, 46 rue Saint Jacques, 75005, Paris, France,
mathieu.cassotti@parisdescartes.fr
Marine Agogué
HEC Montréal, 3000 chemin de la Côte-Sainte-Catherine, Montréal (Québec), Canada H3T 2A7, marine.agogue@hec.ca
Benoît Weil
Center for Management Science, Chair TMCI, Mines ParisTech, 60 boulevard Saint Michel, 75006, Paris, France,
benoit.weil@mines-paristech.fr
Pascal Le Masson
Center for Management Science, Chair TMCI, Mines ParisTech, 60 boulevard Saint Michel, 75006, Paris, France,
pascal.le_masson@mines-paristech.fr

ABSTRACT

There are today large expectations towards creative thinking and innovation in both educational and industrial contexts. Creativity defined as the ability to think of something truly new (i.e., original, unexpected), and appropriate (i.e., useful, adaptive concerning task constraints) is considered as a crucial skill required in numerous organizations and is largely viewed as fundamental process for any innovation. Nevertheless, generating, evaluating and developing new ideas might not be as easy as it seems, and individuals often failed to propose creative solutions to a specific problem, focusing on a narrow scope of existing solutions. Decades of cognitive psychology studies has demonstrated that previously acquired and existing knowledge or ideas can limit creative ideation, leading a phenomena named “mental fixation” or “fixation effect”. Experimental studies with students converged in showing that the fixation effect is reinforced when adults are exposed to uncreative examples of solutions before being asked to generate new ideas. Although, considerable efforts have been devoted at identifying the negative influence of examples on creative ideas generation in experiments made on thousands of engineers’ students, as well as novices from different disciplines, surprisingly there are to date few study that have examined whether examples may constrain (or facilitate) creative ideation in expert engineers or designers. Therefore, the present study aimed to clarify the potential role of expertise in creative idea generation. In this study, 64 expert engineers from a prestigious French Aerospatiale multinational were asked to design solutions to ensure that a hen’s egg dropped from a height of ten meters does not break (the egg task). The participants were randomly assigned to one of two experimental conditions (a control condition without an example or a test condition with an uncreative example) and were given ten minutes to solve the egg task. The problems were identical across conditions, except that the group with an example read the following: "One solution classically given is to slow the fall with a parachute". Our results show that expert engineers were able to overcome design fixation, and interestingly they provided more solutions within the expansion path and fewer solution within the fixation path when they were given an uncreative example. As such, our results expand the understandings of the critical characteristics of expertise for overcoming cognitive biases to creativity, and give new sights to managerial implications for the role of creative leaders in this concern, more specifically when managing innovative processes with team members having varying levels of expertise.

INTRODUCTION

There are today large expectations towards creative thinking and innovation in both educational and industrial contexts (DeHaan, 2011). Creativity defined as the ability to think of something truly new (i.e., original, unexpected), and appropriate (i.e., useful, adaptive concerning task constraints, see Sternberg & Lubart, 1996) is considered as a crucial skill required in numerous organizations and is largely viewed as fundamental process for any innovation (Leenders, Van Engelen and Kratzer, 2007). Nevertheless, generating, evaluating and developing new ideas might not be as easy as it seems, and individuals often failed to propose creative solutions to a specific problem, focusing on a narrow scope of existing solutions (Finke, Ward, & Smith, 1995; Ward, Patterson, & Sifonis, 2004). Decades of cognitive psychology studies has demonstrated that previously acquired and existing knowledge or ideas can limit creative ideation, leading a phenomena named "mental fixation" or "fixation effect" (Cassotti et al., 2016b; Sio et al., 2015; Storm & Angello, 2010; Storm & Patel, 2014). While creative tasks involve the exploration of new and original solutions, people tend to follow "the path of least resistance" and provide solutions based on common and undemanding design heuristics (Agogué, et al., 2014a; 2014b; 2015; Cassotti et al., 2016a; 2016b; Purcell, & Gero, 1996; Finke, Ward, & Smith, 1992; Smith, Ward, & Finke, 1995). Experimental studies with students converged in showing that the fixation effect is reinforced when adults are exposed to uncreative examples of solutions before being asked to generate new ideas. Although, considerable efforts have been devoted at identifying the negative influence of examples on creative ideas generation in experiments made on thousands of engineers' students, as well as novices from different disciplines, surprisingly there are to date few study that have examined whether examples may constrain (or facilitate) creative ideation in expert engineers or designers (Bonnardel, & Marmeche, 2004; Dane, 2010; Jansson, & Smith, 1991). In addition, theses experimental studies have provided discrepant results regarding the role of expertise in creativity. While some studies report that generating creative solutions to a problem is facilitated with expertise (Bilalic et al., 2008; Day, & Lord, 1992), other studies suggest that expertise hinders creative potential (Bonnardel, & Marmeche, 2004; Jansson, & Smith, 1991, Sio et al., 2015). Therefore, the present study aimed to clarify the potential role of expertise in creative idea generation.

Most of social psychology studies have been devoted at identifying social biases in creative thinking. These studies demonstrated that the social environment have a dramatic impact on task engagement that might modulate the creative behavior of adults. According to the intrinsic motivation hypothesis of creativity, developed initially by Amabile (1983, 1996), "the intrinsically motivated state is conducive to creativity, whereas the extrinsically motivated state is detrimental". Therefore, this model posits that social context might lead to a shift from intrinsic to extrinsic motivational state, which in turn would decrease creativity. Initial support for this model comes from studies manipulating the social environment inducing social evaluation (see for a review: Amabile, Goldfarb, & Brackfleld, 1990). Critically, these studies reported that social evaluation and to a lesser extent social surveillance, have a deleterious effect on creativity. Using self-reported measure of intrinsic motivation, an experimental study has demonstrated that both creativity and intrinsic motivation are lower when participant perform the creative task in a typical social evaluation condition compared to a condition in which the evaluation are more informational (i.e. participants expect constructive feedbacks on their performance).

While the aforementioned studies (Amabile, Goldfarb, & Brackfleld, 1990) have examined the influence of social contexts on creativity, converging evidences reported that ideas generation might be also strongly limited by cognitive biases (Agogué, Poirel, Pineau, Houdé, & Cassotti, 2014). In this context, we have recently proposed that a triple-systems model of creativity – much like the ones proposed for decision making – may lead to significant progress in the understanding of the processes involved in creative ideation (Cassotti, Agogué, Camarda, Houdé, & Borst, 2016).

Indeed, reasoning and decision-making research have shown that intuitive thinking is biasing people's judgment in a wide range of situations and tasks (Evans, 2003; Kahneman, 2003; 2011). In general, individuals seem to have a strong tendency to base their judgment on fast intuitive thinking rather than on more demanding reasoning. Although this intuitive or so-called "heuristic" thinking might often be useful, it will sometimes cue responses that conflict with normative logical considerations and bias our decision-making (Cassotti, Habib, Poirel, Aîte, Houdé, & Moutier, 2012). To explain such reasoning biases, authors have postulated the existence of two distinct system of thinking (De Neys, 2006a; 2006b; 2014; Houdé, & Borst, 2015; Kahneman, 2011). These theories generally oppose an intuitive-heuristic system (named System 1) to a deliberate-analytic system (named System 2, Allen, & Thomas, 2011). System 1 operations are typically effortless, rapid, global or holistic and often emotionally charged. System 2, in contrast, is slow, controlled, serial, effortful, and involved cognitively costly strategies. Consequently, these theories predict qualitatively different judgments and decisions depending on which system is running. According to this theoretical framework, cognitive biases evidenced in children, adolescents, adults and experts are not due to a lack of logical skills *per se*, but result from a specific failure to inhibit (System 3) intuitive responses generated automatically by the System 1 (Cassotti, & Moutier, 2010; Houdé, & Borst, 2014, Houdé et al., 2000; 2001).

In line with this theoretical framework, studies in the field of creative thinking attempt to determine the factors leading one to fail to provide original problem solutions in creative tasks. For instance, several investigations have reported that creative problem solving abilities can be impeded by fixation effect (Adamson, 1952; Duncker, 1945; Storm & Angello, 2010). These studies highlighted that previous knowledge or ideas can block the generation of alternative solutions during problem solving. Critically, overcoming fixation is also fundamental in circumstances where people cannot simply choose between existing strategies but must generate a variety of new strategies (DeHaan, 2011). Indeed, it seems that individuals are biased by intuitive reasoning when asked to generate creative ideas (Finke, Ward, & Smith, 1995; Ward, Patterson, & Sifonis, 2004). For example, when they must design methods to ensure that a hen's egg will not break when dropped from a height of 10 meters (32 feet), the findings revealed that participants are fixed on a limited number of response categories based on the most accessible knowledge (Cassotti, Camarda, Poirel, Houdé, & Agogué, 2016). Most of the solutions provided by the participants consisted of using an inert device to dampen the shock, protect the egg or slow the fall (e.g., to slow the fall with a parachute), whereas more creative categories of solutions that consisted of using a living object or modifying the natural properties of the egg (e.g., training a bird to catch the egg during the fall or freezing the egg before dropping it) were proposed less often by individuals. This “dark side” of fast and intuitive strategies to creatively generating problem solutions suggested that creative idea generation requires the inhibition of dominant and common ideas within an intuitive and heuristic System 1 to explore new concepts with a generative type of reasoning within a deliberate and analytic System 2. Thus, to provide original ideas to problems such as “the egg task", one must first inhibit the intuitive and dominant paths to solutions that create fixation effects (referring to the first System) and then activate conceptual expansion reasoning (referring to the second System).

These results are also in agreement with the Concept-Knowledge design theory (C-K theory) that allows to model creative reasoning (Hatchuel, & Weil, 2009; Kazakçi, & Tsoukias, 2005; Le Masson, Weil, & Hatchuel, 2010; Reich, Hatchuel, Shai, & Subrahmanian, 2010) and offers an interesting model of mental fixation (Hatchuel, Le Masson, & Weil, 2011). The C-K design theory models the creative process as the interrelated expansion of two spaces (Hatchuel, & Weil, 2009). One space, defined as the Concept Space (C-Space), is tree-structured and describes the progressive and stepwise generation of alternatives. The other space, defined as the Knowledge Space (K-Space), is formed by the network of memorized and activated knowledge that is used for the generative process of concepts in the Concept Space. C-K theory then sets the framework for a design process based on refining and expanding an initial concept by adding attributes stemming from the K space. It offers then a way to characterize different paths of solutions and the pockets of knowledge associated to the different sets of solutions.

Studies converged in indicating that fixation effect is reinforced when adults were exposed to examples of a solution before the generation of new ideas (Abraham & Windmann, 2007; Dugosh, & Paulus, 2005). Nevertheless, we recently demonstrated that exposure to examples does not systematically impede creativity and can, on the contrary, have a stimulating effect (Agogué, Kazakçi, Hatchuel, Masson, Weil, Poirel, & Cassotti, 2014). These apparent discrepancies reported in previous investigation might be explained by C-K theory. Indeed, people tend to generate ideas that are most accessible in memory. This activation of common knowledge could lead to fixation effects (Hatchuel, Le Masson, & Weil, 2011). Consequently, C-K theory assumed that external cues reinforcing the activation of this common knowledge should increase the fixation phenomena. In contrast, examples of solutions that activate knowledge that are less spontaneously accessible should decrease the fixation and therefore stimulate originality. Using “the egg task”, previous experimental studies clearly showed that constraining or stimulating effects of examples depend on the nature of examples proposed before solving the task (Agogué, Le Masson, Dalmasso, Houdé, & Cassotti, 2015; Agogué, Kazakçi, Hatchuel, Masson, Weil, Poirel, & Cassotti, 2014). Indeed, results indicated that the introduction of an example of solutions generated using the most accessible knowledge (i.e. uncreative example such as using a parachute) constrains creativity whereas examples of less spontaneously accessible solutions (i.e. creative example such as using a bird to catch the egg) reduce the fixation effect and stimulate originality. In other words, examples outside of the fixation path led participants to propose more original solutions, whereas example within the fixation path decreased both the number and the originality of proposed solutions.

Besides, in line with C-K theory and the triple model of creative ideation, previous works suggest that the nature of the fixation effect in creative ideas generation develops with age and expertise (Agogué et al., 2015). More specifically, using a qualitative analysis of responses, Agogué et al. (2015) has explored how age and education modulate fixation effect in the egg task presented above. Although most of the solutions given by adults consisted in slowing the fall, protecting the egg or damping the shock, 10-years-old children and adolescents did not spontaneously propose to slow the fall using for example a parachute (Cassotti, Camarda, Poirel, Houdé, & Agogué, 2016). These results indicate that accessible knowledge and design heuristics used to explore potential solutions to the task and leading to fixation phenomena are quite different between children, adolescents and adults even if both children and adolescents do have the knowledge required (e.g. they know what parachutes are and how they work). Critically, although industrial designer students are less fixated than engineer students in the egg task without any constraints, the introduction of an uncreative example reinforced the fixation effect and constrained both industrial designers' and engineers' ability to generate creative ideas. Indeed, industrial designer students who were exposed to an example belonging to the fixation path behaved similarly to engineer students who were not exposed to this type of example (Agogué et al., 2015).

Surprisingly there are to date few experimental investigations that have explored whether examples may constrain (or facilitate) creative ideation in expert engineers (Bonnardel, & Marmeche, 2004; Dane, 2010; Jansson, & Smith, 1991). For example, Bonnardel and Marmeche (2004) reported that influence (positive or negative) of example of solution depends on the industrial designers' level of expertise. Although example based on intra domain knowledge decreases creative capabilities of expert industrial designers, the authors did not observe specific effect in the group of lay-industrial designers. In addition, some studies report that generating creative solutions to a problem is facilitated with expertise (Bilalic et al., 2008; Day, & Lord, 1992).

Research question and hypotheses

In this article, we expand the existing notion of expertise in creativity, by exploring the relationship between expertise and creativity, and more specifically the role of expertise from a design theory-based perspective to overcome fixation effects occurring in creative ideation contexts. To do so, expert engineers from a prestigious French Aerospatiale multinational were asked to design solutions to ensure that a hen's egg dropped from a height of ten meters does not break. Participants were randomly divided in two groups and have to solve either the control version of the egg task or a version including an uncreative example of solution. We reasoned that if expertise increases the tendency of using intuitive thinking (Bonnardel, & Marmeche, 2004; Dane, 2010; Jansson, & Smith, 1991), then the introduction of an uncreative example should impair performance by reducing the exploration of solution within the expansion path and stimulate the exploration of ideas within the fixation path. In contrast, if expertise decreases the blocking effect of familiar solutions as previously reported in the domain of problem solving (Bilalic et al., 2008; Day, & Lord, 1992), then the introduction of an example should increase creative performance by facilitating the inhibition of ideas within fixation, and stimulating the exploration of ideas in expansion.

METHOD

Participants

In the present study, 64 expert engineers from a prestigious French Aerospatiale multinational were asked to design solutions to ensure that a hen's egg dropped from a height of ten meters does not break (the egg task, Agogué, et al., 2014; 2015). The participants were randomly assigned to one of two experimental conditions: a control condition without example of solution and a condition with an uncreative example. Table 1 displays the sex, mean age, and expertise level in years for each experimental condition. ANOVA and Chi-squared analyses indicated that the mean age ($F(1, 61) < 1$), expertise level in years ($F(1, 61) < 1$) and sex (adolescents: $\chi^2 < 1$) were not significantly different between the control condition and the conditions with example. All of the participants provided written consent and were tested in accordance with national and international norms governing the study of human research participants.

Table 1: Characteristics of the sample distribution. Gender, expertise level in years, and mean age distributions for each task condition.

Condition	N	Mean Age (SD)	Expertise (SD)	Boys (Girls)
Control	34	48.9 (7.7)	12.6 (9.2)	30 (4)
With example	29	49.3 (6.7)	12.9 (10.1)	26 (3)

Procedure

The participants were randomly assigned to one of two experimental conditions (a control condition without an example or a test condition with an example) and were given ten minutes to solve the egg task. Regardless of the experimental conditions, participants performed a creative task in which they were given ten minutes to propose as many original solutions as possible to the following problem: "*You are a designer and you are asked to propose as many original solutions as possible to the following problem: Ensure that a hen's egg dropped from a height of 10m does not break.*" (Agogué et al., 2014a; 2014b; 2015; Cassotti et al., 2016). Participants were instructed that there were no right or wrong answers and that they had to provide as many creative solutions to the problem as possible. The problems were identical across conditions, except that the group with an example read the following: "*You are a designer and you are asked to propose as many original solutions as possible to the following problem: Ensure that a hen's egg dropped from a height of 10m does not break. One solution classically given is to slow the fall with a parachute.*". We chose this example because it is an uncreative solution that typically constrains ideation process in novices and students (Agogué, et al., 2014; 2015; Cassotti et al., 2016a). The task was administered silently and individually, and participants had to write down their solutions using short sentences.

To measure the effect of the expertise and the example on creativity in the egg task, we evaluated the participants' answers based on two criteria: fluidity (the ability to generate many solutions, as measured by the number of solutions), and expansion vs. fixation (the ability to provide solutions inside and outside the fixation path). More specifically, to measure fluidity, we counted the number of solutions provided by the participants. When a participant proposed a solution that combined different proposals, we counted each proposal as one solution. We applied a well-validated measurement of originality on the egg task (i.e., expansion vs. fixation) by studying the distribution of solutions in different categories. To do so, a trained rater assigned each solution given by the participant to one of 10 meta-categories (Agogué et al., 2014a; 2014b; 2015; Cassotti et al., 2016). Based on previous studies, three meta-categories (i.e., reducing the shock, protecting the egg, and slowing the fall) met the qualifications for the fixation effect, whereas the other seven did not (e.g., using a living object and modifying the natural properties of the egg). To assess expansion, we then counted the number of solutions provided that were outside the fixation path for each participant. To assess fixation, we then counted the number of solutions provided that were inside the fixation path for each participant. Critically, expansion is a qualitative measure of creativity that is highly correlated with expert evaluations of the ideas using consensual assessment (Agogué et al., 2015; Amabile, Goldfarb, & Brackfleld, 1990).

RESULTS

To examine whether the number of solutions proposed (i.e., fluency) within the fixation path (fixation) and outside the fixation path (expansion) varied according to the experimental conditions, we conducted a repeated measure analysis of variance (ANOVA) with the experimental condition (control vs. with example) as a between-subjects factor and the category of solution (expansion vs. fixation) as a within-subjects factor and we control the results for expertise level. We used the partial eta squared (η_p^2) and Cohen's d for effect size.

This analysis revealed a main effect of the category of solution, $F(1, 60) = 23.03$, $p < .0001$, $\eta_p^2 = .28$, indicating that the participants provided more solutions in the fixation path than in the expansion path. There was no main effect of the experimental condition, $F(1, 60) < 1$. However, there was a significant experimental condition x category of solution interaction, $F(1, 60) = 9.17$, $p < 0.005$, $\eta_p^2 = .13$; see figure 1).

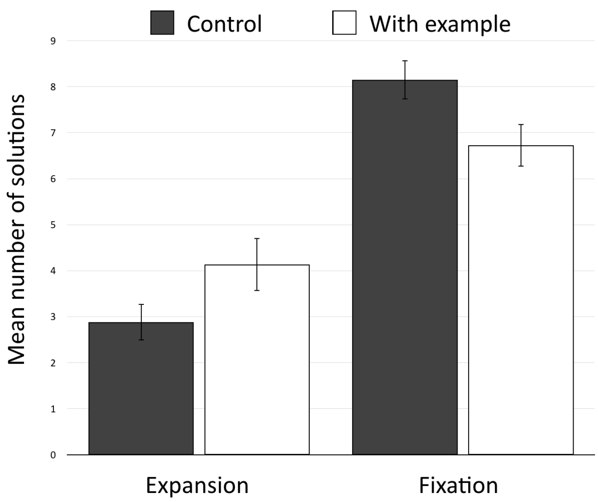

Fig 1. Mean number of solutions according to the experimental condition (control and with example) and the type of solution (expansion and fixation). Error bars represent

standard error of the mean (SEM).

Planned comparisons revealed that the participants in the control group ($M = 8.15$, $SD = 2.49$) proposed more solutions in the fixation path than those in the group with example, ($M = 6.72$, $SD = 2.48$), $F(1, 60) = 5.17$, $p < .05$, $d = .58$. Critically, the participants in the control group ($M = 2.88$, $SD = 2.32$) proposed fewer solutions in the expansive path than those in the group with example ($M = 4.14$, $SD = 3.09$), $F(1, 60) = 4.04$, $p < .05$, $d = .46$.

DISCUSSION

In this article, we explored the relationship between expertise and creativity, and more specifically whether expertise allows to overcome fixation effects occurring in creative ideation contexts. Our results show that expert engineers were able to overcome design fixation, and interestingly they provided more solution within the expansion path and fewer solution within the fixation path when they were given an uncreative example. These findings diverge from previous results of experiments made on thousands of engineers' students, as well as novices from different disciplines, which were noticeably over-fixated when exposed to an uncreative example for the same creative task (Agogué, et al., 2014a; 2015; Cassotti et al., 2016b; Jansson, & Smith, 1991). This results are also in sharp contrast with those of Bonnardel and Mammeche (2004) showing that expert designers but not novice were influence by inter-domain examples. However, our findings are in agreement with studies reporting a higher level of flexibility and a decrease of the blocking effect of familiar solutions during problem solving in experts. In addition, theses results suggest, as expected by the C-K theory, that expert engineers can activate a higher level of knowledge less spontaneously accessible than students increasing their expansive capabilities. Further researches focusing on the activation of these knowledge are required to directly test this interpretation.

Interestingly, expert engineers are strongly influenced by the presence of an uncreative example but this effect is reversed compared to the one observed with engineer students. Indeed, while uncreative example decreases expansion in engineers' students (Agogué et al., 2015), it decreases fixation and increases expansion in expert engineers, directing individuals to avoid solution within the example-related domains. Taken together, theses results suggest that expertise do not only impact generative abilities of expert engineers but also the selection of solutions belonging to the example category. In line with the triple model of creativity (Cassotti et al., 2016), these results are keeping with recent works on conflict detection during thinking suggesting that experts are remarkably good at detecting that their heuristic answers conflict with normative principles (e.g., De Neys, 2006; 2014). These conflict detection studies suggest that reasoners are detecting the biased nature of their judgment: Although people are typically tempted to give the heuristic response, they at least seem to notice that the heuristic response conflicts with logical reasoning and is not fully warranted (De Neys, 2014). That is, conflict detection studies suggest that this feeling of doubt associated with the intuitive reasoning is a necessary but not sufficient condition for triggering the inhibition of bias responses. Following this framework, the introduction of an example might help expert engineers detecting that responses belonging to the example category are low in creativity (conflict detection) and facilitates the inhibition of these type of solutions.

As such, our results expand the understandings of the critical characteristics of expertise for overcoming cognitive biases to creativity, and give new sights to managerial implications for the role of creative leaders in this concern, more specifically when managing innovative processes with team members having varying levels of expertise (Leenders, Van Engelen and Kratzer, 2007). Our findings suggest that expert engineers can be positively influenced by an uncreative example of a solution. If we may conduct an analogy with real-life creative setting, creative leaders focusing on the generation of original and expansive ideas should be aware that when giving a creative task to an individual, both the expertise level and the way the initial brief is framed, might deeply influence performance during creative ideation. Specifically, providing classical solution to expert engineers may facilitate the creative production in terms of the quality of the produced ideas.

CONCLUSION

In conclusion, our results clearly demonstrate that external clues, such as an example of an uncreative solution, can facilitate the detection and the inhibition of the category of example solution, increasing the quality of ideation process to solve a design problem in expert engineers. Therefore, our study provides the first evidences that the introduction of an uncreative example during creative ideas generation, in sharp contrast with previous studies conducted with engineer students showing detrimental effect on creativity of similar example, can have a positive influence on experts' creativity. As such, our results highlighted the need to conduct further studies with expert engineers to increase our understanding of creative ideation in more ecologically settings.

REFERENCES

-Abraham, A., & Windmann, S. (2007). Creative cognition: The diverse operations and the prospect of applying a cognitive neuroscience perspective, *Methods*, 42, 38-48.

-Abraham, A., Windmann, S., Siefen, R., Daum, I., & Güntürkün, O. (2006). Creative thinking in adolescents with attention deficit hyperactivity disorder. *Child Neuropsychology*, 12, 111-123.

-Adamson, R.E. (1952). Functional fixedness as related to problem solving: A repetition of three experiments. *Journal of Experimental Psychology*, 44, 288-291.

- Agogué, M., Le Masson, P., Dalmasso, C., Houdé, O., & Cassotti, M. (2015). Resisting Classical Solutions: The Creative Mind of Industrial Designers and Engineers. *Psychology of Aesthetics, Creativity, and the Arts, 9(3), 313-318.*

-Agogué, M., Le Masson, P., & Robinson, D. K. R. (2012). Orphan innovation, or when path-creation goes stale": a design framework to characterize path-dependence in real time. *Techonology Analysis and Strategy Management*, 24(6), 603-616.

- Agogué, M., Kazakçi, A., Hatchuel, A., Masson, P., Weil, B., Poirel, N., & Cassotti, M. (2014a). The impact of type of examples on originality: Explaining fixation and stimulation effects. *The Journal of Creative Behavior*, 48(1), 1-12.

- Agogué, M., Poirel, N., Pineau, A., Houdé, O., & Cassotti, M. (2014b). The impact of age and training on creativity : a design-theory approach to study fixation effects. *Thinking Skills and Creativity, 11*, 33-41.

-Allen, A.P., & Thomas, K.E. (2011). A Dual Process Account of Creative Thinking, *Creativity Research Journal*, 23(2), 109-118.

- Amabile, T. M. (1983). The social psychology of creativity: A componential conceptualization. *Journal of personality and social psychology*, *45*(2), 357.

- Amabile, T. M. (1996). C*reativity in context*. Boulder, Colorado: Westview Press.
- Amabile, T. M., Goldfarb, P., & Brackfleld, S. C. (1990). Social influences on creativity: Evaluation, coaction, and surveillance. *Creativity research journal*, *3*(1), 6-21.
- Bilalić, M., McLeod, P., & Gobet, F. (2008). Inflexibility of experts—Reality or myth? Quantifying the Einstellung effect in chess masters. *Cognitive psychology*, *56*(2), 73-102.
- Bonnardel, N., & Marmèche, E. (2004). Evocation processes by novice and expert designers: Towards stimulating analogical thinking. *Creativity and Innovation Management*, *13*(3), 176-186.
- Cassotti, M., Agogué, M., Camarda, A., Houdé, O., & Borst, G. (2016a). Inhibitory Control as a Core Process of Creative Problem Solving and Idea Generation from Childhood to Adulthood. *New directions for child and adolescent development*, 151, 61-72.
- Cassotti, M., Camarda, A., Poirel, N., Houdé, O., & Agogué, M. (2016b). Fixation effect in creative ideas generation: Opposite impacts of example in children and adults. *Thinking Skills and Creativity*, *19*, 146-152.
- Cassotti, M., & Moutier, S. (2010). How to explain receptivity to conjunction-fallacy inhibition training: Evidence from the Iowa Gambling Task. *Brain & Cognition*, 73 (3), 378-384.
-Cassotti, M., Habib, M., Poirel, N., Aîte, A., Houdé, O., & Moutier, S. (2012). Positive emotional context eliminates the framing effect in decision-making. *Emotion*, 12(5); 926-931.
- Dane, E. (2010). Reconsidering the trade-off between expertise and flexibility: A cognitive entrenchment perspective. *Academy of Management Review*, *35*(4), 579-603.
- Day, D. V., & Lord, R. G. (1992). Expertise and problem categorization: the role of expert processing in organizational sense-making. *Journal of Management Studies*, *29*(1), 35-47.
- De Neys, W. (2006a). Automatic-heuristic and executive-analytic processing during reasoning: Chronometric and dual-task considerations. *The Quarterly Journal of Experimental Psychology, 59,* 1070-1100.
- De Neys, W. (2006b). Dual Processing in Reasoning: Two Systems but One Reasoner. *Psychological Science, 17,* 428-433.
- De Neys, W. (2014). Conflict detection, dual processes, and logical intuitions: Some clarifications. *Thinking & Reasoning***,** 20, 169-187.
- Dugosh, K.L., & Paulus, P.B. (2005). Cognitive and social comparison processes in brainstorming. *Journal of Experimental Social Psychology*, 41, 313-320.
- Duncker K. (1945). On problem-solving. *Psychological Monographs*, 58(5, Whole No. 270).
- Evans, J. S. B. (2003). In two minds: dual-process accounts of reasoning. *Trends in Cognitive Sciences, 7,* 454-459.
- Evans, J. S. B. (2006). The heuristic-analytic theory of reasoning: Extension and evaluation. *Psychonomic Bulletin & Review, 13,* 378-395.
- Evans, J. S. B. (2011). Dual-process theories of reasoning: Contemporary issues and developmental applications. *Developmental Review*, *31*(2), 86-102.
- Finke, R.A., Ward, T.B., & Smith, S.M. (1992). *Creative cognition: Theory, research, and applications.* Cambridge, MA: MIT Press.

- Hatchuel, A., Le Masson, P., & Weil, B. (2011). Teaching Innovative Design Reasoning: How C-K Theory Can Help to Overcome Fixation Effect. *Artificial Intelligence for Engineering Design, Analysis and Manufacturing*, 25(1), 77-92

- Hatchuel, A. (2001). Towards Design Theory and expandable rationality: The unfinished program of Herbert Simon. *Journal of Management and Governance*, 5(3), 260-273.

- Hatchuel, A., & Weil, B. (2009). C-K design theory: an advanced formulation. *Research in Engineering Design*, 19(4), 181-192.

- Houdé, O., Zago, L., Crivello, F., Moutier, S., Pineau, A., Mazoyer, B., et al. (2001). Access to deductive logic depends on a right ventromedial prefrontal area devoted to emotion and feeling: Evidence from a training paradigm. *NeuroImag*e, 11, 1486–1592.

- Houdé, O., Zago, L., Mellet, E., Moutier, S., Pineau, A., Mazoyer, B., et al. (2000). Shifting from the perceptual brain to the logical brain: The neural impact of cognitive inhibition training. *Journal of Cognitive Neuroscience*, 12, 721–728.

- Landau, J.D, & Leynes, P.A. (2004). Manipulations that disrupt generative processes decrease conformity to examples: Evidence from two paradigms. *Memory*, 12(1), 90-103.

- Landau, J.D., Thomas, D.M., Thelen, S.E., Chang, P. (2002). Source monitoring in a generative task. *Memory*, 10(2), 187-197.

- Leenders, Van Engelen and Kratzer .(2007). Systematic Design Methods and the Creative Performance of New Product Teams: Do They Contradict or Complement Each Other? *Journal of Product Innovation Management*, 24(2), 166-179.

- Jansson, D. G., & Smith, S. M. (1991). Design fixation. *Design studies*, *12*(1), 3-11.

- Kahneman, D. (2003). A perspective on judgment and choice: Mapping bounded rationality. *American Psychologist, 58,* 697-720.

- Kahneman, D. (2011) *Thinking fast and slow*. Farrar, Straus and Giroux.

- Purcell, T., & Gero, J. S. (1996). Design and other types of fixation. *Design Studies*, 17(4), 363-383.

- Sio, U. N., Kotovsky, K., & Cagan, J. (2015). Fixation or inspiration? A meta-analytic review of the role of examples on design processes. *Design Studies*, *39*, 70-99

- Smith, S.M., Ward, T.B., & Schumacher, J.S. (1993). Constraining effects of examples in a creative generation task. *Memory and Cognition*, 21, pp. 837-845.

- Smith, S.M., Ward, T., & Finke, R.A. (1995). *The creative cognition approach*. Cambridge, MA, USA: The MIT Press.

- Sternberg, R. J., & Lubart, T. I. (1996). Investing in creativity. *American psychologist*, *51*(7), 677.

- Storm, B. C. & Angello, G. (2010). Overcoming fixation: Creative problem solving and retrieval-induced forgetting. *Psychological Science, 21,* 1263-1265.

- Storm, B. C., & Patel, T. N. (2014). Forgetting as a consequence and enabler of creative thinking. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40,* 1594-1609.

- Ward, T.B., Patterson, M.J., & Sifonis, C.M. (2004). The role of specificity and abstraction in creative idea generation. *Creativity Research Journal*, 16(1): 1-9.