

Assessment of the Research on Problem-Solving and Insight

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This literature review explores the extent of research on problem solving and insight, as well as the roles of conscious and unconscious processes. This paper looks at the research on the structure of how insight develops and in general the problem-solving process. Next, the type of problems are examined as to which type of problem solving task work best using either conscious or unconscious processes. Then, this paper covers research on probabilistic reasoning as this may be an unconscious process and the role of memory and sleep may have in problem solving and insight. To conclude, there are areas that still need further research but there is strong evidence of an integral role of unconsciousness processes in problem solving.

Keywords: Cognitive Psychology, Problem-Solving, Insight

The purpose of this literature review is to explore the extent of research on the topic of problem solving and insight and the roles of conscious and unconscious processes. The implications of this topic mean a better understanding of the conscious and unconscious processes and how best to maximize our problem solving and decision making. We can be able to explain how insight occurs and why it happens. This literature review will review first the structure of problem solving and insight, then the types of problems and association in problem solving, probability reasoning, and lastly, the role of memory in problem solving. By going through this framework, we can examine the topic of conscious and unconscious processes. The research has shown strong support for the role that consciousness in problem solving and support for even unconsciousness in problem solving and insight.

The Structure of Problem Solving and Insight

Some of the philosophical aspects as to the structure of conscious and problem-solving are presented by Jaques and Hutchinson. Jaques (2003) speaks largely of how the definition of conscious and unconscious is not true when talking about living organisms. He proposes that conscious should be more work-based, meaning work in the sense of judgment, decision making, and choice making towards an intended goal is an unconscious process. The unconscious process is ineffable and Jaques finds the concept of unconscious in psychoanalysis to be too limiting. We think of conscious and unconscious as a dichotomy. Jaques propose that all living organisms live “unconsciously” but humans have the evolved brain structures to all for us to live “consciously” in which he proposes the five orders of increasing complexity of information that humans use in constructing the worlds they live in. The proposal of the five orders of complexity can attribute to talking about the varying ideas of the process of conscious and the unconscious and the role of decision making.

Hutchinson (2014) looks more closely with the topic on insight. Though he does not talk much about quantitative studies, he uses a more qualitative approach. As he explores the nature of insight through the many different accounts of scholars, artists, and members of society. The four stages or phases of insight is explained as: “A Period of Preparation, Trial and Error Activity; A Period of Renunciation of the Problem during which effort is temporarily abandoned; A Period (of Moment) of Insight; and, A Period of Verification, Elaboration, or Evaluation” (Hutchinson, 2014, p. 216).

Hutchinson’s focus is the Moment of Insight and thus, talks about the many ways insight seems to come about; activities dissociated from the work in hand, sleeping, listening to music, and physical activities. Hutchinson also talks about two types of accidental stimulus that may set off insight on the accord of the accounts of others who had insight; the accidental stimulus or idea is consciously related to the problem are at once incorporated as part of the work or the “key” to the problem or the accidental event is not used in the final product but merely acts as a catalytic agent in which other ideas are fused into union and thus, insight. Hutchinson also talks about the many forms of insight; verbal, visual imagery, inner hearing, etc. This relates to the Unconscious Thought Theory later and of course, further studies on the different processes or functional problems or goals that are required for problem-solving and insight. For example, Chaves-Eakle’s commentary (2007), she speculates the role of the cerebellum and creativity in problem-solving. Other studies such as Ansburg (2000) and Zhong, Dijksterhuis, & Galinsky (2008) looks at the creativity, and more specifically, association in the process of problem solving and the possible rise of insight.

Before delving into the different theories of the right environment and type of problems involved with insight and problem solving, we should explore what the literature says about the insight problem-solving process. Much like the proposed four stages or phases of Insight by Hutchinson, Ash & Wily (2006) talks about the insight problem-solving process that involves three phases; an initial representation phase, where the solver inappropriately represents the problem; and initial search through the faulty problem space that may lead to impasse; and a post impasse restructuring phase. There are some theories in which the controlled search processes is used, whereas other theories suggest that restructuring is achieved through automatic redistribution of activation in long-term memory. To test their hypothesis, that the correlation between working memory span scores and success at the restructuring stage of the insightful problem-solving process can be used to test the predictions of different accounts of restructuring. Ash & Wily used an individual-differences approach and tested for the relationship between insight problem-solving success and working memory span measures.

This study used two types of problems. One version of the problems was designed so that success would depend on the entire insightful process (Many Moves Available problems) whereas the other version was designed to reduce the size of

the initial faulty search space, basically isolating the post impasse restructuring phase (Few Moves Available problems). The other conditions were the controlled search and the automatic activation. The researchers defined that if “[...] the controlled search theories of restructuring are correct, we would predict that WM span measures should be positively related to solution success on all problems, because higher capacity to control attention should lead to better performance at both initial search and the restructuring phases”. They also defined that “[...] if the automatic activation accounts of restructuring are correct, we would predict an interaction of WM span and the number of moves in the initial faulty problem space on problem-solving performance [...] [there would be] no relationship between WM span measures and problem-solving success on the problems in which the restructuring phase has been isolated”. The results showed support for the automatic restructuring theory. The authors proposed an explanation they found this kind of finding; the problems were so easy that they did not tax the attentional capacity of solver but there was not ceiling effect and the overall difficulty was similar across the Many Moves Available and Few Moves Available problems. There was an unexpected finding where individuals with higher spans seemed to be more likely to succeed on the Many Moves Available than on the Few Moves Available problems, whereas individuals with lower spans seemed less likely to succeed on the Many Moves Available than on the Few Moves Available problems, suggesting that in some problem situations, increased attentional ability might facilitate restructuring processes.

When talking about the stages of insight, an empirical study by Siegler (2000) looks at the boundary of unconscious insight in testing second graders. Siegler and colleagues asked questions like “Do insights arise at an unconscious level before they arise consciously, and do insights arise suddenly or gradually?” in which they constructed their study to answer these questions. The second graders were presented arithmetic problems that involved the inversion task. There were two experimental conditions; the blocked-problems (presenting inversion task arithmetic problems $[A + B - B]$ in which there is a shortcut), and the mixed-problems condition (presented both the inversion tasks problems and other problems $[A + B - C]$). The children were on both their solution times (the time it took for them to write the correct answer) and their explanation of the strategies they used, which were identified into three categories (Computation [more than 4s and said they computed the answer], Shortcut [took 4s or less to answer and said they used the shortcut], and Unconscious shortcut [took 4s or less to answer and said they computed the answer]). Results showed that almost 90% of the children of both conditions used the unconscious shortcut before reaching the shortcut category. They followed the trend where they started from the computation category to the unconscious shortcut before being consciously aware of the shortcut, thus making into the shortcut category.

Findings demonstrate that insights are not always conscious from the start and that insight can be abrupt in some sense but also gradual in another sense. Criticisms of the study includes the worry of the verbal report of children may not be reliable but Siegler acknowledges this problem and explains that the solution times is the additional measure in which that can be used to attest for the findings of the level of unconscious and conscious. Implications include whether these findings can

apply to adults, if the unconscious insight is limited to single-step strategies or can be used for multiple-step strategies, and what the cognitive process are used in unconscious insights. By exploring the boundaries of the insight and problem-solving and the minimal contrast between the conscious and unconscious processing, we can learn a lot more about the process that is involved with problem solving and what give rise to insight.

In relation to Ash & Wiley’s study, Baars’s general analysis (2010) on “mind wandering” and the spontaneous repetitive thoughts looks at rumination and in a way, memory. Baars states we must be careful using the term “mind wandering” for task-unrelated thoughts because we may fall into the trap of believing that spontaneous thoughts are task-unrelated in the deeper level. It is found through other studies that spontaneous thoughts are rich and self-relevant, which can reflect on what we think every day at any given time. This can be thought of rumination but not in the sense of always thinking of depressing or negative thoughts. These repetitive thoughts occur underlying our conscious and may have common themes with one another, thus mathematicians, chess players, and other problem solvers spend a lot of time dwelling on repetitive ideas but the results can be highly functional. This ties in with Deheane’s Global Workspace Theory in which “global broadcasting” is triggered by conscious events. The conscious thought draws upon a larger domain of unconscious long-term memories, semantics, and automatic mental routines. This is a very general overview of the relationship of conscious and unconscious and how the two processes work together as one major system. Though this may seem contradictory to the Ash & Wiley study, there are further studies done that explored the type of problems and task loads that starts to show a relationship with the Ash & Wiley study and Baars general analysis, as we will get to in the next sections. As you may see in the Lassiter, Lindberg, Gonzalez-Vallejo, Bellezza, & Phillips (2009) study, the unconscious “mull it over” may enhance decision making, thus leading and providing support to the Deliberation-Without-Attention effect.

In conclusion, the stages of insight include an initial stage where you may try to solve the problem but to no avail, the second stage in which you put the problem away and go about doing other things, the third stage where you have your “a ha!” moment, the insight to the solution of the problem, and the last stage in which you try to fill in the gap and verify the solution of the problem, as proposed by Hutchinson. Ash & Wiley propose a three-stage process that is very similar. They and Baars talk about the use of memory and how our unconscious draws upon them and then brings the finished product or the solution to consciousness. The study done by Siegler is a good example in which it shows the process in which insight comes about by testing the question like if the prior workings of insight is unconscious and when does it becomes conscious.

Creative Problem Solving and Association

When looking at how problem-solving works and when insight occurs, we must look at the kind of problems that occurs in which we use our problem-solving skills. Ansburg (2000) proposed four general problems in which they used to look at the production of problem solving and insight. The four types of problems they used were insight problems, analogies, series-completion problems and the Remote Association Test. The purpose of the study was to define the processes that give rise

to insight. By picking the four different types of problems, they could look at the results and see if there is a pattern or consistency between the problems that are similar to each other and those that are different. The tests were given in a randomized order and were timed in the appropriate amount of time to finish each test. Ansburg (2000) found a positive correlation between the series-completion problems and the analogy problems which suggest an underlying skill is shared between the tests. The series-completion and the RAT did not show a correlation between the two, indicating no shared skill.

Ansburg discuss how the participants in the study who were capable of apprehending relations on non-insight problems generally were able to solve insight problems. This study looks at different kinds of problems in which different problem-solving processes make work better. However, when Ansburg speaks of a shared underlying skill, there was not much evidence or clarification of what the said underlying skill was. It can only be inferred as to what the skill is by looking at the nature of the problem and not looking at the problem-solving processes.

In a comparison, a study by Zhong, Dijksterhuis, & Galinsky (2008) looks more deeply in the minimal contrast in problem solving by using Remote Association Test. They looked more closely at the effect of unconscious thought on the two outcomes of Remote Association Test: implicit accessibility and conscious reporting of answers. Given that association is the nature of the Remote Association Test, the researchers used this as a skill in problem-solving. The researchers proposed that incubation is a two-step process, “unconscious thought associates and creates the novel idea or solution to the problem” (Zhong, et. Al, 2008, p. 913), and this solution is transferred consciousness. The general hypothesis is that unconscious thought would be better at associative search than conscious thought but the products of the unconscious thought may not reach consciousness. The Remote Association Test problems is justified to be suitable because prior studies done have shown that “[...] accessibility of RAT answers does not always correlate with conscious production of those answers” (p. 913). Thus, the more precise hypothesis is that the unconscious thought about Remote Association Test answers would increase their mental accessibility, but this increased deep activation might not translate into expression of the correct answers. As there was a criticism that expectation may impact the problem solving, the researcher included a third condition in which another group were distracted, just like the unconscious-thought condition, but were not given a problem-solving goal. The results showed no difference between conditions except for the response latencies in which the unconscious-thought group exhibited shorter response latencies and thus great accessibility of Remote Association Test answers. These results were consistent with and provide support for the Unconscious Thought Theory proposed by Dijksterhuis, Bos, Nodren, & Van Baaren (2006), as we will later see in next section, in which the theory proposes that conscious thought is better at making linear, analytic decisions, but the unconscious thought is especially effective at solving complex problems.

A criticism to the first experiment done by Zhong and others was the concern for an effect of the Bayesian theory, meaning that unconscious thought in solving Remote Association Test problems should be most prominent when the problems involve remote or weak association, whereas,

conscious thought is prominent in strong association. In response to this criticism, the researchers set up a second experiment in which was almost the same except that they used more moderately difficult Remote Association Test problems. In the first experiment, the researchers purposefully selected Remote Association Test problems that were extremely difficult so that the increased accessibility could not be attributed to anything but differences between thought processes. Like Experiment 1, the results showed the unconscious-thought group had shorter response latencies and thus, supported the researchers’ predictions that unconscious thought can facilitate discovering remote, but not local associations and even further speculated by the researchers, supports that problem solving is goal-based. Though there is evidence in support, the researchers in their discussion were bold to say that their findings show direct evidence for a causal relationship, which perhaps may be true but I say that it is bold because there is not enough research searching this specific area to provide similar and accurate support to make kind of judgment.

The two studies done by Ansburg (2000) and Zhong and others (2008) both looked at association and the performance of problem solving in using association. Ansburg used different types of problems and the results have shown that some problems were highly correlated with each other suggesting that there may be an underlying skill used for those problems while there are some problems that have no relation to each other, suggesting they may use different skills. Both studies used the Remote Association Test, in which the Zhong study used solely to test their hypothesis. The results of this study have shown support for the Unconscious Thought Theory which will be talked about later. This research showed further evidence that the conscious and unconscious problem-solving processes may differ from each other.

A Modal Preference in Creative Problem Solving

On a side note but an interesting study worth mentioning and the only one that addresses modality in problem solving, Deininger, Loudan, & Norman (2012) did their study with thinking about the problem and physical manipulation of the problem. In the first condition, the participants could choose which method they would like to use in solving the puzzle, whether by thinking about it or using a mouse to manipulate the puzzle on the computer screen. The second condition, the participants were to think about the puzzle and solve it that way. They were asked later which mode they would have preferred if they could choose. In the third condition, the participants had a choice in what modal they wanted to use for the puzzle and were to tell the experimenter when they had solved the puzzle. If their verbal response was correct, though the actual shape had not been made or completed, the time was stamped. All the conditions were timed in how long it took to solve the puzzle and afterwards were given a questionnaire about their problem-solving preferences. Deininger and others have found that of those who had a choice, 85% chose to play (manipulation on computer). 95% said they would have preferred the “real” shapes. Of those who played, 80% got the answer correct, those who thought, 70% got the answer correct but with a faster time. The participants overwhelming preferred manipulation which could be explained by our natural tendency to interact, even indirectly, with world we are in. Further questions arise with this study in which I would

suggest research may open up more answers. Such questions could be, “is there a relationship between the preference of modal and the performance with specific modal”, or “What modals would work best for specific problems and problem-solving”.

The methods of this study do have limitations, in which, if there are future studies, can easily address. This study used manipulation by using it on a computer screen rather than the puzzle being a physical object we can hold. Another limitation in which more studies can easily address the issue, is the population. Graphic design students were used in the first three conditions and in response, a fourth condition was used in which there were not design students and was exactly like Condition 3. The population used in this study also translate that the finding may not be generalized due to the size and the type of participants, the graphic design students, used.

The Effects of Task-Load in Problem Solving and the Unconscious Thought Theory

As mentioned before, Dijksterhuis, Box, Nordgren, & Van Baaren (2006) takes the approach of the Unconscious Thought Theory. The theory proposes that conscious thought is better at making linear, analytic decisions, but the unconscious thought is especially effective at solving complex problems. The researchers set up a series of studies to test the hypothesis predicting that simple choices produce better results after conscious thought, but that choices in complex matters should be left to unconscious thought, bringing to name the “Deliberation-Without-Attention” hypothesis. In the first study, four hypothetical cars were used, each with four or twelve attributes. There was a clear distinction between car in which one was better, average, and worst in the proportion of positive and negative attributes. The participants were randomly assigned to two conditions; conscious and unconscious, a similar modal as Zhong and others (2008) in which the unconscious thought condition was given a task for a certain amount of time to distract them from actively thinking of the problem. The participants were asked to deliberate (or not, depending on the condition they were in) and state which was the best car.

The Deliberation-Without-Attention hypothesis was supported by the results as the unconscious thinkers fared relatively well and the conscious thinkers did well in the simple task-load in getting the correct answer but their performance plummeted for the heavier task-load. The other study was a survey of customers from IKEA and a department store, asking questions about their purchase, how long they thought over the purchase before buying it, and how expensive it was. A few weeks later, a follow-up survey asked the customers’ satisfaction level with their purchase. The surveys showed that the conscious thinkers from the department and the unconscious thinkers from IKEA showed more satisfaction than the other groups. This was consistent with the Deliberation-Without-Attention hypothesis because purchase from the department store were classified as simple choices given the nature of products and the purchases from IKEA were more complex choices. These series of studies explore the boundaries of conscious and unconscious problem-solving in the simplicity and complexity of problems. However, I see there is some problem with the last study, (the one with IKEA and the department store), in that it was a survey that was given *after* the experience. Therefore, it is not quite accurate to say

or be sure that the experience was what the customer remembers it to be and the results are relying a lot on subjectivity. However, the research done by Zhong and others (2008), provide more support, at least in relation to the car study, where the results showed the unconscious-thought group exhibited shorter response latencies and great accessibility when tested with the Remote Association Test.

The Unconscious Thought Theory explained by the Deliberation-Without-Attention Effect is tested even further by Lassiter, Lindberg, Gonzalez-Vallejo, Bellezza, & Phillips (2009). These researchers propose another interpretation of the Unconscious Thought Theory in which they argue that, “[...] rather than establishing the existence of a deliberation-without-attention effect, is explained more compellingly in terms of the well-established distinction between on-line and memory-based judgments” (p. 671). The first experiment was an opposite of the study from Dijksterhuis and others (2006), in which participants in one condition were asked to make an impression of the four cars presented to them and the other condition, participants were asked to memorize the attributes, hence the two judgment types, on-line and memory-based. The second experiment was a duplication and also included the Need for Cognition Scale, an individual difference measure of the participants’ tendency to engage in effortful thought. The results of this research provided more support that Unconscious Thought Theory paradigm is plausible and the researchers suggests based on the result that the Deliberation-Without-Attention is more artifact than fact, as explained by the on-line and memory-based judgments. As discussed with Ash & Wiley (2006) and Baars (2010), the concept of working memory and the role of rumination or memory replay may play a role in the problem-solving, or in this case, making a judgment.

In their discussion, the researchers made a point that judgments are ultimately a product of conscious because the Need for Cognition showed that those who rate high are thought to have to consciously think through problems as compared to those who rated low. However, the data collection and thus, the results were unclear in that there could be multiple interpretations for the results. The researchers made note that the present results could be explained by the unconscious thinking postulated by Unconscious Thought Theory, thus not clarifying the differing interpretations of the Unconscious Thought Theory. The Need for Cognition Scale used in the second experiment may discount this though and this remains under scrutiny for research.

The types of problems are explored in this section. The Unconscious Thought Theory proposes that the conscious problem solving is good for analytical thinking and simple problems whereas the unconscious problem-solving process is good for the complex problems. This was highly supported by Dijksterhuis and others (2006), Zhong and others (2008), and Lassiter and others (2009). Lassiter and colleagues proposed that the Deliberation-Without-Attention effect, as proposed by Dijksterhuis and colleagues, may in fact, be an artifact rather than fact. They talked about the on-line and memory-based judgments which both make use of working memory and long-term memory. This can go back to the relation with the conscious and unconscious processes in problem solving and association. Our performance on trying to solve a problem may be depending on the type of problem it is and our conscious and unconscious processes. In accordance with the

Unconscious Thought Theory, our ability to “weigh” our options or go with the best answer in a complex problem works better if it is an unconscious process.

Probability Weighing and Hypothesis Forming in Problem Solving

So, given that the Unconscious Thought Theory is supported and became the mainstream explanation or theory of problem solving, we should look at the deeper process in the unconscious problem solving and the role of probability and hypothesis formation in problem solving and decision making. Payne, Samper, Bettman, & Luce (2008) examined complex decision making and the boundary conditions of unconscious thought. This research branches from Dijksterhuis and others. (2006) in which they in which they demonstrated that one should delegate thinking about complex decision problems to the unconscious. The deliberate decision strategy is referred to as expected-value (EV) or weighted additive (WADD) model, meaning that decision involves uncertainty, beliefs about event likelihoods and considering all the necessary information to come down to the correct solution or answer to the problem or decision. The experiment had three thought conditions; conscious thought for a fixed time (CT-FT), self-paced conscious thought (CT-SP), and unconscious thought (UCT). The decision-making task is replicated from the Dijksterhuis and others (2006) study. The three thought conditions were tested in two choice environments. In one environment (Game A), there was the option with the largest number of positive attributes that was selected more often the UCT condition than in CT-FT condition. The other environment (Game B) has the magnitudes of the attributes altered to create a more substantial dissociation between the number of positive attributes and the highest EV was selected more often in the CT-SP than in the other conditions.

An older study done by Stein (1966) looks at rule of thumb development, or in other words, developing partially correct hypothesis. Stein’s hypothesis for this study was that the participants would get more correct answers than expected if they respond randomly, using their partially correct hypothesis, and any performance gains that occurred before correct verbalization of the principle could be accountable for by (a) comparing the performances with a control group, (b) using a more precise definition of awareness or consciousness, and (c) assessing the effects of partially correct hypotheses. The participants were presented a list of words and they were to answer a number between numbers one to nine and would be told if they got the number right or wrong by the experimenter. After each trial block, the experimenter would check to see what the participants’ partially correct hypothesis was at the time. The partially correct hypothesis that were responded were classified as; the answer made explicit the word-number combination involved, state a relationship between some quality of the word and the number associated with it, the principle that would lead to the same number no matter who applied it. The study made use of reinforcement in which the experimental group were systematically reinforced for knowing if their answers were right or wrong. The control group, however, were randomly reinforced with no basis of a system for the word and number pair. This is like the study on the second-graders done by Siegler (2000) in terms of the similar methodology. Though testing different hypotheses,

these studies make use of the stages of insightful problem solving and the role of the unconscious.

The results showed that the first hypothesis was supported. The successful group showed initial consciously mediated performance gains which they maintained until just prior to criterion, after which their performance decreased significantly and rose sharply which was suggested by Stein that the decline may have been the participants giving up on their partially correct hypotheses, which were not consistently reinforced. I am a bit more skeptical of this study because Stein omitted the correct answers and based their data from the omission of correct answers for an unclear reason. The results may not be as accurate as believed to be.

Stein made use and explored the process in which we use an underlying hypothesis and in a sense, a use of probability. Looking at rhesus monkeys and conducting a study using logarithms in which the monkeys had to choose between a pair of colored targets after viewing four shapes, have shown that the monkeys learned to combine probabilistic information from the shape conditions. The four shapes were shown sequentially and the sequence governed the probability that one of the targets would furnish a reward. The results showed a direct confirmation of these theoretical insights for the first time as they demonstrate directly that the firing rates of the Lateral Interparietal area neurons are proportional to the logLR conferred by the shape stimuli. Some explanations are that the brain might approximate the logLR associated with each shape on the assumption of conditional independence or that the subject WOE- the quantity the researchers derived from their behavioral analysis and could be based on the systematic error in the monkeys’ choices.

If we use probabilistic reasoning, then the role of semantics and numerical value must be important. Can multiple digits be processed at a semantic level without awareness, either serially or in parallel? This may mean that there is more to problem-solving, if we are able to process the semantics of numerical digits as part of the process. Van Opstal, De Lange, & Dehaene (2011) studied just this in two experiments in which the participants were presented with two set of four simultaneous Arabic digits. The first set was masked and served as a subliminal prime for the second, visible target set. The participants had to determine from the target set either the mean or sum of the digits and compare it to the reference value (smaller or larger than 5 [mean] or 20 [sum]). The results showed that the participants applied the instructions to the entire set of digits that was presented below their conscious threshold, if they were congruent with the target digits. In less than 800ms, the participants successfully approximated the addition and mean tasks, even though they tended to overweigh the large numbers particularly in the sum task. The findings extend the previous observations of ensemble coding by showing that set statistics can be extracted from abstract symbolic stimuli and that it can be represented without awareness. This can also be extended back to the association in problem-solving in which our use of semantics creates a large network of local and remote associations and thus we draw upon these in our problem-solving.

Earlier in their introduction the researchers talked about serial and parallel processing which in the experiments and discussions, they failed to address it at all. As a follow up study, one may want to try to address the serial and parallel

processing as it may be in relation to the idea of the bottleneck theory and the processes of unconscious and conscious.

Our unconscious seems to do a lot of statistical and probabilistic reasoning that really helps our problem solving immensely. Payne, Samper, Bettman, & Luce (2008) have found that the unconscious thought group performed well in the condition which they chose the option with the most number of positive attributes more. In the second condition, the researcher used the magnitude of the positive attributes in which the conscious self-paced chose the better option more. The study done by Stein (1966) researched the rule of thumb, meaning, the partial-hypothesis formation. This is well related to Siegler's study (2000) on second grader's in which he tested how long it took for the solution to the math problem to become conscious and at what point did the participants start answering the problem correctly more than chance. The ability for probabilistic reasoning is supported by the study in which the brain scans of rhesus monkeys using logarithms showed the lateral interparietal area neurons firing. Another such is the usage of semantics in which we are able to attach a value to something and further weigh it in our probabilistic reasoning, as Van Opstal and colleagues studied.

The Physiology of the Brain with Sleep and Problem Solving

To get into even more precise research of problem solving and the role memory plays in problem solving, studies on certain brain areas have provided strong support. Research by Ji & Wilson (2007) looked at the multicell spiking patterns in both the visual cortex and hippocampus during slow-wave sleep in rats. It was found that spiking patterns not only in the cortex, but also in the hippocampus were organized into frames, defined as periods of stepwise increase in neuronal population activity. The multicell firing sequences evoked by awake experience were replayed during these frames and the replay events in the cortex and hippocampus reflected the same experience. This implies the simultaneous reactivation may contribute to the memory consolidation process and thus, may play a role in problem-solving. Like what Baars (2010) had said in his general analysis, the rumination or replaying memories strengthen those memories and thus enhances our problem solving and give rise to insight, as it is further supported by Wagner, Gais, Haider, Verleger, & Born (2004).

In further studies with sleep and how it may impact problem-solving and more specifically, insight, Wagner, Gais, Haider, Verleger, & Born (2004) conducted a study that shows facilitating role of sleep in the process of insight. As supported by Ji & Wilson, sleep consolidates recent memories and other researchers further suggests that it could allow insight by changing their representational structure. In the study done by Wagner and others (2004), the subjects performed a cognitive task requiring the learning of stimulus-response sequences, in which they improved gradually by increasing their response speed across task blocks. The initial training establishing a task representation, was followed by a full 8 hours of nocturnal sleep, nocturnal wakefulness, or daytime wakefulness. Then the subjects were tested again. The results showed the more than twice as many subjects gained insight into the hidden rule after sleep as wakefulness, regardless of time of day. It was concluded that sleep, by restructuring new memory representations, facilitates extraction of explicit knowledge and insightful behavior. The study ruled out the effects of sleep

deprivation, circadian rhythm, or proactive influences of sleep on subsequent capability of problem-solving because of the methodology and the use of the control conditions.

Multiple studies have looked at the role of working memory and the involvement of the cerebellum in creativity, which contributes to problem-solving, as it is thought to be a highly distributed brain system performance. Chavez-Eakle (2007) in her commentary work on this topic speculates that it is possible that combining the working memory model and the dynamic models of the cerebellum for studying creativity has potential of gaining better understanding of the transition between conscious and unconscious during creativity. By combining the two models, we can gain a better understanding of the incubation stage where we can learn how information becomes accessible. The cerebellum is where motor and cognitive information are processed, which can be a possible link to the explanation as to why understanding and insight are sometimes gained through movement by anyone.

This section looks at the brain areas and the role of sleep in memory consolidation as it enhances and plays an integral part in problem solving and insight. Rumination or memory replay as talked about by Baars (2010) is further supported by Ji & Wilson in their study which showed the numerous multicell spiking patterns that are found in the visual cortex and the hippocampus in the sleep cycle that mirrors the similar activity when awake, suggesting memory replay and further memory consolidation. Wagner and colleagues (2004) further provided evidence of the role of sleep and the performance on insight and problem solving. The role of the cerebellum in the many studies talked about by Chavez-Eakle (2007) may contribute to the highly distribute brain system performance. Working memory is highly supported to play a hand in the problem-solving process.

Conclusion and Discussion

In conclusion, the research in the roles of conscious and unconscious processes in problem solving and insight have made some major headway. There are strong evidence supporting the theories on the stages of insight, as examined by Ash & Wiley (2006) and Siegler (2000). There has been research in the kinds of problems in which certain processes work best. In terms of association, Ansborg (2000) and Zhong and others (2008) have shown a difference in the conscious and unconscious processes in problem-solving. The results of these studies supported the Unconscious Thought Theory, which proposes that the conscious problem solving is good for analytical thinking and simple problems whereas the unconscious problem-solving process is good for the complex problems. This was further demonstrated in the study done by Dijksterhuis and others (2006) and Lassiter and others (2009). There is some speculation of whether the Deliberation-Without-Attention effect is the explanation of the Unconscious Thought Theory. There is an argument suggesting the effect is an artifact rather than fact that can be explained by on-line and memory-based judgments. Though there is some criticism for the study that suggests this, due to the fact that the results were unclear in clarifying a precise interpretation about the Deliberation-Without-Attention effect.

However, there is something to be said about the role of memory and probabilistic reasoning in problem solving and the rise of insight as an unconscious process. Studies like Tianming & Shadlen (2007) and Payne and others (2008)

demonstrate a significant role of weighing the probability and numerical value at an unconscious level. The Van Opstal and others study (2011) ties together nicely the semantics of numbers, suggesting the combination of probabilistic reasoning and semantic memory. Other research on memory replay and consolidation in sleep have shown a higher prevalence in insight and problem solving. The role of working and long-term memory, as well as semantics can be further supported by the studies on the association and problem solving.

I thought it was worth mentioning the modal preference in a problem-solving task. In my search, I did not come across any other related studies in which preference for a specific mode of problem solving and its impact on the performance on solving a problem. I started the research on this topic from March to April 2015. The databases I searched were PsychINFO, PsychARTICLES, and Academic Search Complete. And the keywords entered were (*modality) or (*problem solving) or (*insight) and (*modality preference) or (*types of problems) or (*mode of problem) or (*problem mode) or (*problem modality). I believe there may be some major implications if there are further research on this specific topic as it would help us gain a better understanding how to maximize our problem solving and decision-making skills as well as the kind of processes involved.

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