Think Outside the Box:
The Effects of Cognitive Training on Creative Problem Solving

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Abstract

Problem solving requires the use of higher mental functions, functions that can be improved with training (Brown, Ryan, & Creswell, 2007). The current study examines the effects of *meditation* on creative problem solving. Participants were undergraduate students (n = 81) who were randomly assigned to meditate or rest. Next, Pp were asked to solve a problem: fishing out a small object from inside a box using one of four available tools. Two of the available tools were potentially useful, but the other two were intentionally designed to be useless (i.e., they were incapable of retrieving the object). There were no differences between meditators and non-meditators with respect to solution rates, tool switching behavior, or overall persistence. However, meditators spent more time with their first tool that they selected, and more time attempting to solve the task with the useful tools. Brief meditation training may promote certain cognitive strategies that are conducive to successful problem solving; implications are discussed.

Keywords: problem solving; cognitive training; meditation.

Introduction

Recently, investigations have demonstrated that *cognitive training*, activities designed to improve performance, self-control, and brain physiology, provides an effective method for improving a variety of higher order mental functions including reasoning, decision-making, and task-set switching (Basak, Boot, Voss, & Kramer, 2008; Mestre, Dufresne, Gerace, & Hardiman, 1993; Willis et al., 2006). Research suggests that a broad range of cognitive training techniques is effective. Manger, Eikenland, and Asbjornsen (2002) were able to improve the social-cognitive functioning of female schoolchildren with a 9-month long social-cognitive training program. Basak et al. (2008) utilized 23.5 hours of training using a real-time strategy video game, and found that the training improved task switching, working memory, and reasoning. Smith et al. (2009) found that a computerized cognitive training program improved attention and memory of aged adults. Indeed, these and many other studies demonstrate that cognitive training can improve cognitive performance in a variety of areas when used over the long term.

The study described here investigated a very specific form of cognitive training called focused *meditation*, a process where a person attempts to sustain attention on a selected thought, detect mind wandering, and return to focused attention. Meditation is a form of cognitive training, and studies have demonstrated the benefits of meditation on cognitive functions (Ramsburg & Youmans, 2011; Tang et al., 2007; Zeidan, Johnson, Diamond, David, & Goolkasian, 2010). Meditation techniques are also relatively simple to teach, and some research has demonstrated measurable improvements in cognitive function even with very little meditation experience. Ramsburg and Youmans (2011) found that initial periods of meditation that lasted only six minutes at the start of a class lecture improved academic performance amongst lower division college students. Tang et al. (2007) found that five 20-minute sessions of meditation reliably improved attentional functioning, while Zeidan et al. (2010) found improvements in attentional functioning, working memory, and visuo-spatial processing with only four sessions of meditation training.

Problem solving and meditation?

General problem solving skills involve an ability to understand a problem, devise a plan of action, execute the plan, and examine the results (Newell & Simon, 1972). An important question in the problem solving literature is whether the individual steps within the problem solving process can be enhanced, and the answer it would seem is ‘maybe.’ For example, we know that experts in a given domain are often superior to novices at both understanding a problem and devising a plan of action. However, we also know that when the rules of a domain are compromised (e.g., impossible chess positions) or when an expert in one domain is asked to perform a task in a different domain, so-called 'experts' often fail to *transfer* their expertise between the two domains (Ohlsson, 2011).

Although meditation has been shown to improve a variety of cognitive functions, relatively few studies have directly examined the influences of meditation training on problem solving (Dillbeck, 1982; Kindler, 1979; Raingruber & Robinson, 2007). Kindler (1979) found that group problem solving could be improved with meditation training, specifically, improving speed to solution and promoting effective teamwork. Raingruber and Robinson (2007) found using a qualitative approach that nurses engaged in meditation training reported improvements in their problem solving abilities, attention, and calm. These findings suggest that meditation *might* be an effective method for improving problem solving, but more study is clearly required.

If meditation were to enhance problem solving, we hypothesize here that its influence might be most pronounced on the actual execution of any given problem solving strategy. Whereas expertise is likely to act on the stages of problem solving that require accurate problem framing (i.e., understanding problems and devising solutions), meditation and other types of cognitive training might have positive effects on some of the key cognitive processes utilized while trying to execute a plan of action during problem solving (Lutz et al., 2009; Mayer, 1992; Tang et al., 2007; Zeidan et al., 2010). Ly and Spezio (2009) found via fMRI that meditation could improve decision-making by influencing neural circuits in an enduring manner for recruitment during the self-regulation of social cognitive processes. Other studies have demonstrated that mediators appear to display more conscientious decision making (Kirk, Downar, & Read Montague, 2011), or cognitive flexibility, a mental ability important in problem solving (Dillbeck, 1982; So & Orme-Johnson, 2001). These and other studies suggest a link between meditation and other forms of cognitive training, and the cognitive functions used during problem solving itself.

In this study, we examined the effect of meditation, a form of cognitive training, on a real-world, creative problem-solving task. Participants received either brief meditation training or rest, and then attempted to solve a novel creative problem. Although past studies have shown only moderate training benefits on problem solving tasks (e.g., Kershaw & Ohlsson, 2004), we hypothesized that meditation, which has been shown to improve cognitive functioning (So & Orme-Johnson, 2001; Tang et al., 2007) may be an effective method for promoting creative problem solving in general.

Method

Participants

Eighty-one California State University, Northridge students participated for course credit. Participants had an average age of 18.73 with a standard deviation of 1.32. There were 61 females and 20 males. Participants identified themselves as Latino/Hispanic (45.7%), Black/African-American (19.8%), Caucasian (19.8%), more than one race/other (6.2%), Asian or Pacific Islander (4.9%), and Middle Eastern (2.5%).

Problem-solving task

The researchers developed a novel creative problem-solving task. The task was a physical problem that required the use of unique experimenter designed tools to solve the task. Specifically, the objective was to get a bolt out of a box and across a red line (six and a half feet away from the box) using the four experimenter designed tools.

Materials

Box and Bolt. The box (see Figure 1) was made using 5 ½ by ¾ inch wood, a 16 inch in length, 3 inch high, and 1/16 inch thick piece of clear flexible plastic, and a 23 by 18 inch plywood base. The back face of the box measured 17 ¼ inches. The two wooded sides measured 23 inches in length. The clear plastic front piece with red tape lining its top was 3 inches high and was glued into place 16 ½ inches from the back side of the box, which left two 6 ¾ inch in length non encased walls. A modified 5/8th inch lag bolt was the target that participants were trying to retrieve. The bolt was placed standing upright inside the box at the beginning of each experiment. The bolt was 3 inches in length had seven 1 ¾ inch washers secured by two 5/8th inch nuts.

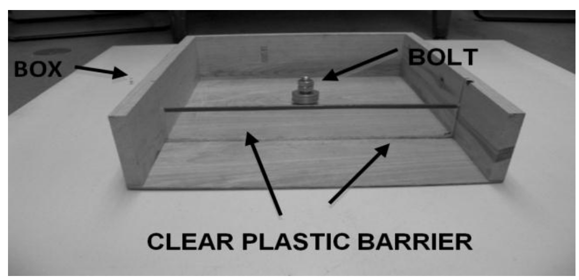

Figure 1. The Box with the Bolt in the Starting Position.

Claw. The claw was one of the two tools that were capable of retrieving the bolt (see Figure 3). It consisted of a modified metal grabber extension tool. The claw was 53 ¾ inches long. A piece of thin rope connected the "trigger" at the handle, and the grasping claw. The grasp of the claw was weak, making the straightforward method of using the tool to retrieve the bolt difficult, but not impossible.

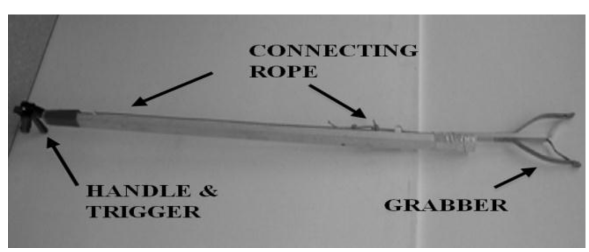

Figure 2. The Claw.

Magnet. The magnet was the second tool that was capable of retrieving the bolt (see Figure 4). It consisted of a 35 ½ inch long PVC pipe that was 1 ¼ inches in diameter that was connected to another PVC pipe that was 12 inches in length. The two pieces of PVC pipe were joined by a spring that was 5/6 inch diameter and 8 inches long. A rope was laced through the top that hung 34 ½ inches. At the end of the rope was a 2-inch diameter magnet. The magnet was too weak to lift the bolt outright, but it could be used to drag the bolt. Using the magnet and loose string in combination, it was difficult, but possible, to retrieve the bolt.

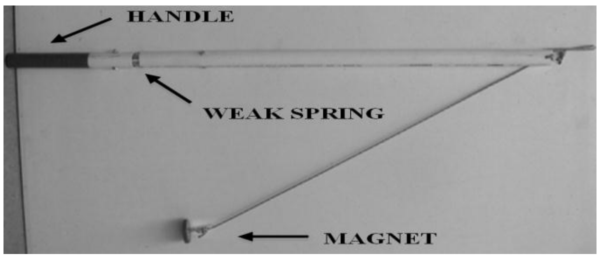

Figure 4. The Magnet.

Spatula. The spatula was one of two tools that were not capable of retrieving the bolt. It consisted of a 49-inch long piece of flexible PVC pipe that was 5/8 inches in diameter had a plastic paint scrapper fastened to one end by three screws (see Figure 5). The other end had a less flexible PVC pipe that was 11 ½ inches long and 5/8 inch in diameter attached. At each of these ends was a 23 ½ inch long PVC pipe that would serve as the handles for the tool. The flexibility of the tool made the tool useless.

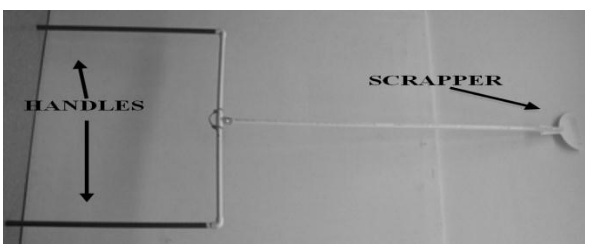

Figure 5. The Spatula.

Ring. The ring was the second tool that was not capable of retrieving the bolt. It consisted of a 48-inch long fiberglass rod that was 1/8 inches in diameter where at one end of the rod a thin rope was attached that was 44 inches in length (see Figure 6). At the end of the rope a 4 ½ inch long heavy-duty carabineer was tied; this carabineer served as the 'ring' that participants would use for 'hooking' the bolt. The shape of the ring made the tool useless.

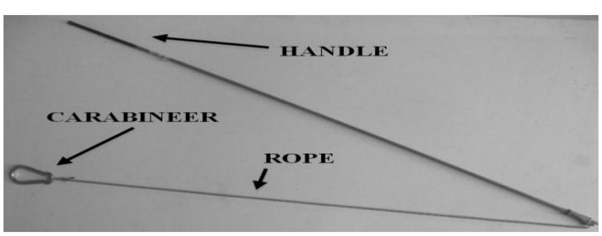

Figure 6. The Ring.

Self Report Measures. Six items administered pre and post examined feelings of tension, ease, anxiety, self-confidence, nervousness, and overexcitement measured on five-point likert scales (1 = Not at all to 4 = Very Much So). Additionally post measures for 'how difficult was the task?' (1 = very difficult to 5 = very easy) and 'how frustrating was the task?' (1 = very frustrating to 5 = not frustrating) were recorded.

Video Camera. A handheld digital-video camera on a stationary platform was used to record tool switch behavior and allow for an objective measure of time.

Design & Procedure

The study was an experimental design. Participants entered the laboratory individually and were given consent forms to review, after which, they were given a brief mood questionnaire. This was followed with a 10-minute audio recording of eyes closed guided meditation or eyes closed rest.

Following the 10-minute training participants received instructions for the creative problem-solving task. Participants were informed that they would be participating in a creative problem-solving task with the objective to remove a bolt from a box and bringing it across a red line using four experimenter-designed tools. Importantly, participants had to obey the following four rules: 1) you must stay within the red box when using a tool 2) you can only touch the red and black parts of the tool when in use 3) you can only use one tool at a time 4) you can switch tools back and forth at your own discretion. Any participant that had questions or needed clarification was given further instruction if necessary for understanding the task and rules.

The participants were informed that the camera would be recording tool usage. When a participant either solved the task or quit the camera was turned off and the participant then filled out questionnaires assessing mood, perceived frustration of the task, perceived difficulty of the task, and demographics information. Finally, participants were debriefed and thanked for their time.

Results

The hypothesis was that meditation training would result in successful completion of the task. For those that failed to solve the task meditation would result in greater initial persistence, overall persistence, and fewer tool switches. Tool use behavior was also examined in order to determine favoritism in tool usage. No significant differences were found for mood, $F < 1$, frustration, $F(1, 78) = 1.17$, *ns*., or task difficulty, $F(1, 79) = 1.3$, *ns.* The results revealed no significant difference in success rates between meditation (36.59%) and rest (35%), χ^2 (81) = .02, *ns*. Overall tool success rates were as follows: claw (20.99%), magnet (13.58%), spatula (0%), and ring (0%; see Figure 7 for results by condition).

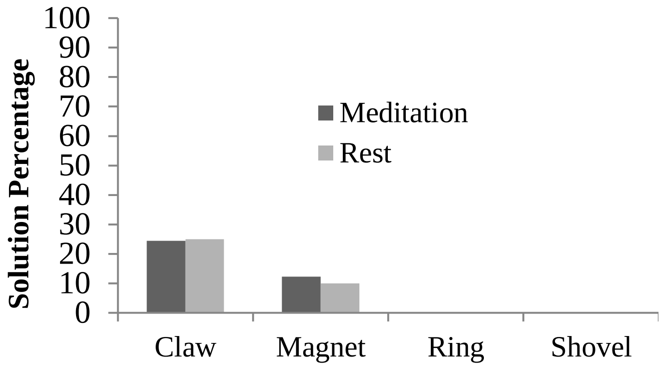

Figure 7. Success rates by tools, split by condition.

Of the remaining 52 participants that failed to solve the task, 51 were used in the other analyses. One was removed due to lost data. The meditation condition (*M* = 60.44 seconds, *SD* = 29.21) compared to the rest condition (*M* = 43.62 seconds, *SD* = 20.79) spent significantly more time with the first tool, $F(1, 49) = 5.65$, $p < .05$. No reliable differences were found between the meditation condition (*M* = 722.64 seconds, *SD* = 534.2) and the rest condition (*M* = 790.69 seconds, *SD* = 539.06) for total time spent, $F < 1$. No reliable differences were found between the meditation condition (*M* = 7.52, *SD* = 3.72) and the rest condition (*M* = 7.73, *SD* = 3.52) for tool switch behavior, $F < 1$.

In a series of follow-up analyses, we examined tool use behavior. Specifically, the time participants spent with the useful tools (i.e., tools that were successfully used to solve the task, the magnet and claw) and the useless tools (i.e., tools that no one could solve the task with, the spatula and ring), in order to, determine whether participants favored the useful over the useless tools. Post-hoc Tukey's HSD tests showed that meditators spent more time with the useful tools (*M* = 436.88 seconds, *SD* = 420.07) then the useless ones (*M* = 227.13 seconds, *SD* = 227.62), $p < .05$, and that resters had no reliable differences between time with the useful tools (*M* = 372.82 seconds, *SD* = 310.02) compared to the useless ones (*M* = 276 seconds, *SD* = 303.56), $p > .05$; see Figure 8). In sum, success rates did not differ between groups, nor did overall persistence, or tool switch behavior, but those that meditated had a greater initial persistence, and spent more time with the useful tools then the useless tools, where resters did not differ in tool use preference.

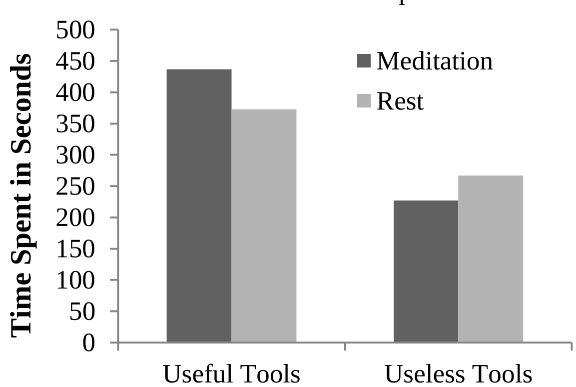

Figure 8. Time spent with tool types by condition.

Discussion

Although our hypotheses were not fully supported, the findings suggest that meditation training might promote some important behaviors useful in problem solving. One could view the enhancement in initial persistence as taking the time to get to know the problem, and spending more time with the useful tools might suggest that meditators were recognizing what tools appeared to be getting them closer to the goal. Nonetheless, problem-solving success did not differ between the groups, but was higher than anticipated with 1/3rd of both conditions completing the task. However, the 1/3rd success rate may be low enough to demonstrate the difficulty of the task, where ratings of task difficulty did not differ between groups. One might expect that the meditation training might improve mood or reduce frustration with the task since meditation is often associated with better mood and less anxiety (Brown et al., 2007), but the brevity of the training as seen in other studies using limited training measures does not consistently result in improvements in mood (Ramsburg & Youmans, 2011).

In order to gage persistence we had to eliminate those that had solved the task because their times would reflect time to solution, and not persistence. When we examined persistence among those that failed to solve the task, we found no differences between the groups, which might suggest that brief meditation training does not enhance persistence. However, when examining initial persistence we found that those receiving the meditation training spent significantly more time with their initial chosen tool, perhaps, suggesting a need to become more familiar with the problem before attempting the task with other tools.

Notably, of the four tools available to the participants, two of the tools could be used to solve the task (claw and magnet) and two were useless (spatula and ring). We found that participants in both conditions did not differ in the number of switches they made, suggesting similar levels of flexibility. However, a closer inspection of the amount of time with the various tools revealed that meditators spent more time with the useful tools, whereas, the resters had no reliable difference in how they spent their time attempting to solve the task. The increase in time for useful tools among meditators may have resulted from recognition of their value for solving the task, perhaps as a result of improvements in cognitive functioning. Conceivably, attentiveness for usability of one tool over another might lead those with meditation training to use the tools that appear to be more effective given that meditation training is associated with improved attentional functioning (Tang et al., 2007). Nonetheless, more research is needed to determine what aspects of cognitive functioning might most benefit from meditation training when faced with a problem-solving task and whether success rates might increase with extensive training.

A problem with the present study that makes further interpretation of the results difficult stems from the finding that meditators did not improve in overall problem success.

One admittedly post-hoc explanation might be related to the observation that succeeding in this particular problem solving task actually required that participants not only select the tools that made the task possible, but use them in non-traditional ways to retrieve the bolt. Research suggests that chunk decomposition and constraint relaxation can account for success with creative or insight problems when faced with an impasse (see Knoblich, Ohlsson, Haider, & Rhenius, 1999). Chunk decomposition relates to the ability to unpack chunks of information to where detailed approaches can be vested. Constraint relaxation involves the ability to reduce the severity of constraints that may occur when faced with a problem. These processes appear to be activated via successive failures that elicit further decomposition and greater constraint relaxation. To be a successful problem solver in the present study, a participant would need to relax the constraints associated with how the tool can be used because solutions require participants to use the useful tools in a non-normal fashion in order to achieve the goal (e.g., the claw's grasp is ineffectual, but with some maneuvering the claw could be used like a shovel). Additionally, problem solving success may depend on decomposition of chunks associated with the possible strategies that when chunked are unsuccessful, but when decomposed may provide novel strategies (i.e., a chunked strategy can involve many steps that are thought of as one process, but when the steps are isolated novel divergent approaches could be adopted by combining different steps from different strategies). More broadly, a participant would need to think divergently, which is not a process influenced by meditation training, although thinking divergently is a process associated with some eastern philosophies that utilize meditation training (see Dogen, 2007). Our participants were only exposed to a brief 10-minute meditation exercise absent eastern philosophical approaches that expound divergent thinking. As such, in the absence of an enhancement in divergent thinking, neither group could be expected to think more creatively.

Future Research

The present study presented findings that may suggest cognitive improvements with some aspects of problem solving. However, the present study did not adequately determine what underlying mechanisms cognitive training via meditation influenced. Future research might investigate what components of cognitive functioning, influenced by meditation, are responsible for enhancing problem solving. For instance, past research has shown that meditation can enhance creativity (Jedrczak, Beresford, & Clements, 1985; Travis, 1979), attention (Lutz et al., 2009), memory (Kozhevnikov, Louchakova, Josipovic, & Motes, 2009), and self-regulatory functioning (Brown, Ryan, & Creswell, 2007), but less is known about the applicability of these benefits to problem solving. Understanding how the training influences performance will help in determining how the training might be used and whether certain aspects of the training should be emphasized over other options.

The present study utilized a unique physical problem-solving task, with the objective of determining whether meditation training could improve creative problem solving performance. The results of the experiment left more questions than answers, demonstrating the breadth of studies that could follow, which might better clarify the processes responsible for the benefits seen in the present study. For instance, a brief ten-minute training exercise may have produced some benefits to problem solving; one might infer that more extensive training might further enhance performance, where deliberate practice has been known to enhance performance amongst novices and experts (Ericsson et al., 1993).

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