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Can Brain Training Through Replicating a Three-Dimensional Object Improve Visuospatial Performance?

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By Rachael Rice

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Abstract

Studies have shown that cognitive training improves brain function. There are many forms of training that have been used to improve brain function from recalling a list to improve memory, using aerobic exercise to increase brain activation, to increasing the ability to talk in nonverbal autistic children. Training the brain and focusing on one task can also improve untargeted areas of the brain. This study uses the understanding of how perceiving biological movement of hands and how working with one's hands can activate the superior temporal sulcus to create a brain training task that will activate and improve participants visuospatial perception. Participants completed a 6-day training task of either replicating their hands in clay or completing crossword puzzles. By completing a mental rotation task, the improvement or no improvement after the brain training was recorded. There was no significant difference found in improvement of reaction time in the control or experimental group. Regarding improvement of accuracy, the experimental group had a larger improvement in scores, but there was no significance found in the improvement scores and groups. There was a positive correlation between improvement of accuracy scores and improvement of clay hands. The correlation between improvement of clay hands and accuracy scores and the interaction between improvement of accuracy scores and group were approaching significance. Together these results suggest that in future studies the training should be longer and more intensive with a larger participant size to see a significant improvement in mental rotation scores, resulting in improvement of visuospatial perception.

Introduction

Proper brain function affects how people live and execute their day to day tasks. Most tasks that people do can be related to at least one cognitive function of the brain. These tasks range from simple to complex body motions (motor skills) (Forster et al., 1996), remembering necessary tasks and sequences that one may be presented with during their day (working memory) (Ball et al., 2002), to fitting various objects of different shapes and sizes into a confined or limited space (spatial perception)(Shutts, Ornkloo, Von Hofsten, Keen & Spelke, 2009). When cognitive function works the way it is supposed to, the day goes smoothly with few mishaps and minimal frustration. However, if one's cognitive processes are functioning improperly, the day can become more muddled and difficult.

Cognitive Training

Through specific training tasks, one can improve their brain function, improving their quality of life. The brain controls everything you do from being able to talk to people to catching a ball. Studies show that if one works out their brain, like how one can work out their body, their brain will become stronger and work better, improving one's ability to do day to day tasks. In studies that use cognitive training to improve brain function, they normally have participants come in and partake in a brain training task that focuses on improving one part of brain function that can be applied to real world use (Ball et al., 2002). In a 2002 study by Ball and Colleagues, they looked at how cognitive training with older adults can improve their brain function and inherently improve their abilities in day to day task: remembering shopping or a to-do list (verbal episodic memory), identifying patterns in schedules (problem solving with serial patterns), and focusing on a task while ignoring distracting factors (visual search task).

Cognitive training is found to be particularly effective in groups of people with cognitive decline. An environment with low or limited stimulus can create a place where weak or declining cognitive function thrives, in contrast to an active stimulus in life which keeps the brain strong and healthy. (Churchill et al., 2002). Studies have found that using cognitive training to create a more stimulating environment has helped older people maintain and improve healthy brain function (Willis, 1989). The researchers saw an improvement within the tested skills and predicted that through training over a longer period they would see an increase in ability to apply the transferable skills from improvement in the lab to daily life tasks (Ball et al., 2002). With cognitive training, people who have a cognitive decline will have a more whole life again by restoring the brain activation levels to that of earlier years, than those who avoid brain training.

In addition to improved function of daily tasks, studies have shown that with cognitive training symptoms of neurological disorders like inattention in ADHD (Klingberg, Forssberg, & Westerberg, 2002), poor reading comprehension in dyslexia (Shiran & Breznitz, 2011), and behavioral problems in down's syndrome (Bennett, Holmes, & Buckley, 2013) could be lessened through improving brain function that counteracts undesired symptoms. Neurological disorders come from the brain not functioning the way it needs to be, making those who are impacted by the disorders rely on medication to function properly. Studies have seen an improvement of cognitive function from partaking in cognitive training tasks which can eliminate the impairments of neurological disabilities and potentially make the need for certain medications unnecessary. Within ADHD, the symptoms of inattention, hyperactivity, and impulsivity can be traced to a deficit in the function of working memory which attributes to the ability of logical reasoning and problem-solving (American Psychiatric Association, 1994; Engle, Kane, & Tuholski, 1999; Hulme & Roodenrys, 1995). In a 2002 study, Klingberg, Forssberg, & Westerberg found that through a training task participants were able to improve working memory on both trained and untrained tasks (Span board, Stroop task, Raven's progressive matrices, and Choice reaction time task). Shiran & Breznitz (2011) concluded that through recall span and speed of processing tasks, participants with dyslexia were able to improve their ability to store verbal and visual-spatial information and increase their reading rate and comprehension scores (Shiran & Breznitz 2011). Bennett, Holmes and Buckley (2013) had 21 children with down's syndrome participate in visuospatial working memory training that improved their visuospatial short-term memory which correlated with a reduction of problem behaviors found in children with difficulties in executive function. Within these studies, experimenters were able to find links between improving cognitive function and reducing symptoms. The participants were not given a task to target a symptom they had, but they were given a task focusing on a brain function that impacted their symptoms.

Some studies have found that after completing a training task, there is improvement found in targeted areas (areas that the training is supposed to directly impact) and untargeted areas (areas that were not trained to be improved). In the 2008 study by Terlecki, Newcomba & Little, after playing Tetris for several weeks, participants had improvement in mental rotation as well as the untargeted tasks, Guilford-Zimmerman Spatial Visualization Task and Surface Development Test, focusing the transfer of mental rotation to other abilities. This provides the question; can one intentionally train for an untargeted area? To know that, researchers look at correlations between deficits and improvements of brain function. A study by Vleet and DeGutis (2013) take the understanding of the deficits in non-spatial attention influence spatial attention and have 16 participants with chronic non-spatial attention deficit complete a Tonic and Phasic Alertness Training. All participants had significant improvement in untrained spatial and non-spatial visual attention. In a 2009 study, Holmes and colleagues found that brain improvement in untrained areas can be more beneficial than medicinal treatment. Holmes and colleagues (2010) had 25 children complete a variety of working memory tasks focusing on verbal short-term memory, verbal working memory, and visuospatial memory. For medication, the participants were prescribed for ADHD that improved the participants visuo-spatial memory performance. But when the participants were medicated with additional training interventions, there was a significant increase in their performance than with just medication. When using a training task that focuses on one cognitive function, there may be improvements in an untrained brain function which was previously thought to be uncorrelated. This interaction is relevant to the study because the brain is activated in many areas to perform one task. Through understanding the correlations of tasks and brain activation, cognitive training tasks can be applied to an action or task used to improve something that was thought to be unrelated.

For example, the act of aerobic exercise can increase fitness, and some studies found that cognitive function can also be improved (Best 2010; Chaddock et al., 2012; Thomas et al., 2016). In recent studies there has been a link between higher academic achievements and larger brain structures within children. In a study done by Chaddock and colleagues (2012), children were assessed on their fitness level and then completed an Eriksen flanker task. In this study, 32 children were placed into two categories (low fit and high fit), depending on whether the child's max oxygen intake levels during aerobic exercise, above the 70th percentile or below the 30th percentile. The children’s brains were mapped with an fMRI, while they completed the Eriksen and Flanker task, a 20-trial task, consisting of a row of arrows displayed on a screen pointing either to the right or left. During the task, participants had to indicate which direction the middle arrow was facing. Participants who were in the high fit condition had more activation in their left & right middle frontal gyrus, supplementary motor area, anterior cingulate, and left & right superior parietal lobe, then the low fit children, leading to the conclusion that participants with higher fitness levels had more brain activation than those with lower fitness levels. Physical activity activates brain regions linked to learning and memory (Holmes, 2006). The act of working out does not require one to complete a brain test during it, but by being physical one is activating their brain and cognitive functions like goal-directed problem-solving (Best, 2010). In another study, Thomas and colleagues (2016) had 62 adult participants partake in a 6 week long training program for 5 days a week cycling on a bike and maintaining their heart rate within their training zone. Participants completed a compilation of cognitive tests to assess their brain function: Osterrieth Complex Figure Test (replicating a complex line drawing), Rey Verbal Learning Test (word list recall), Center for Epidemiological Studies Depression inventory (self-report on how one has felt in the past), letter and lematic frequency (detect target letters while reading a text), and forward and backward digit span (remembering and recalling a sequence of numbers). Participants had brain scans throughout the study with an MRI. After the study, there was an increase in hippocampal volume within the participants, showing that increasing brain volume can happen at any age. The use of aerobic exercise can improve cognitive function and brain volume without having it be the target task for the participants. Cognitive function and brain volume can be improved by aerobic exercise that was presumed to be unrelated. Knowing that completing a task not focused on the brain can improve brain functions, it opens an avenue of different brain training tasks being used.

On the basis that being given a training task can improve a target function as well as an untargeted function, researchers are exploring new ways to improve cognitive function through training. Some studies use tasks within the arts to improve the brain (Moreno et al., 2011; Sandiford, Mainess, & Daher, 2013). A study by Moreno and colleagues in 2011 used musical training to gain a look at neural plasticity and cognitive function through music training over the course of 4 weeks, 5 days a week in 2 daily 1-hour sessions. 71 children between 4 and 6 years old completed the Wechsler Preschool and Primary Scale of Intelligence-III (an intelligence test for children that reports on the verbal and spatial intelligence) and a go/no-go task for their testing conditions before and after the training. The training was of 2 conditions (musical and visual), consisting of computerized tasks focused on motor, perceptual and cognitive tasks through rhythm, pitch, melody, voice, and basic musical concepts. The musical training was focused on listening activities, and the visual training focused on visual arts through the development of visuospatial skills applied to concepts of shape, color, line, dimension, and perspective. After the training, within the musical therapy group, there was an increase in verbal ability and verbal intelligence. Participants in the visual-art training condition had an improvement in their spatial skills. The brains of participants were improved by training focused on different practices and skills of the arts, then with traditional means of cognitive training. This type of cognitive training can also reduce the symptoms of neurological disorders, faster and more efficiently than with traditional cognitive training.

Sandiford, Mainess, and Daher (2013) conducted a study on 12 children with nonverbal autism were either Melodic Based Communication Therapy (MBCT), where a melody is associated with a target word, or traditional therapy. Both groups received 5 weeks of training to assist in remembering and recalling words. In the traditional therapy group, participants would be informed of a word and trained/rewarded on their performance, using reinforcers. In the MBCT group, participants had 3 reinforcers to help train and reward them though the training process, in addition to listening to a words melody while being given the stimulus item at the same time. As the training went on the task participants had with the words became more complex for MBCT participants: just listening to the recording, a series of steps leading to independent clapping, a combination of clapping and singing, singing independently, to answering the sung question “What is this?”. Both groups had a greater ability in verbal skills. Participants in the MBCT group had more improvement in their ability to state correct words than participants in the traditional therapy group. The idea that the use of Melodic Based Communication Therapy comes from the understanding as to how the developing brain in children with symptoms of Autism. Even though children with Autism exhibit deficits in their language development, their musical capabilities are often intact (Brenton et al. 2008). The right part of the brain is associated with musical abilities (Ono et al., 2011), while the left side of the hemisphere is associated with language (Knecht et al., 2000) and has weaker activation than the right side in children with Autism (Herbert, 2004). By activating the stronger hemisphere of the brain in participants, MBCT was able to get participants thinking about language through understanding musical and rhythm with the activation of the right hemisphere, activating the left hemisphere just enough to make it stronger without strain and improving the ability to talk without focusing on it. In all tasks we do, the brain activates in specific areas in correspondence to the action. By understanding, the correlation of actions and brain activation there is potential in completing actions with the focus of improving specific brain functions instead of using traditional brain training. Similarly, to how muscles are activated, while working out, if the brain is being activated it is becoming stronger and inherently the cognitive functions located within that region of activation will be improved.

Brain Activation

Understanding how an action can light up certain parts of the brain will help researchers know what activities to use to promote increased cognitive function in participants. Studies have shown that there is a link between spatial attention in auditory and visual function (Spence & Driver, 1996). Eimer and Driver conducted a study on analyzing the link in spatial attention pertaining to vision and touch. Their study consisted of 14 participants who came into the lab to complete a task consisting of 24 sections with 96 trials in each of both visual and tactile stimuli. When the visual stimuli were presented in the “judge-vision condition” and “vision-primary condition”, participants were shown blocks on a screen and had to respond yes or no to whether the stimuli were in the targeted section of the screen. The tactile stimuli would give a small shock to one of the participants hands. In the “judge-touch condition”, participants had to respond verbally whether they felt a shock on the targeted hand, while in the “vision-primary condition”, they had to respond if they felt the shock on either hand. During the task, participants were connected to an EEG that recorded their brain function. Their findings showed that there is a link in spatial attention between vision and touch only when the tasks are related or relevant to each other. This leads to the question if a tactile task is relevant to the visual stimuli would the task be additionally focused on.

In a study 2003 by Beauchamp and colleagues, they addressed this idea of the interaction between vision and touch by running a study looking at the brain function while perceiving human motion and motion of objects. To observe the interaction between brain activation and perception of motion, participants were presented 4 types of motion stimuli video form (humans moving, tools moving, human moving with only certain points being displayed, and tools moving with only certain points being displayed). In the stimulus where only, certain points were being displayed, the points were chosen based on the spots of bend in the human and tool. While viewing the stimulus, the participants were connected to an fMRI recording their brain activation. Participants also completed a task where they had to quickly discriminate between whether the stimulus was a tool or human. They were faster in determining the stimulus when viewing the object then when only certain points were displayed. In addition, participants were faster in viewing the stimulus with moving points then when the points were stationary. When perceiving a moving object specifically a biological one, participants were quicker at recognizing what the object was with activation located in the STS (Perrett et al., 1988).

The STS is activated while perceiving biological movement (Allison, Puce, & McCarthy, 2000), especially when one perceives motion of a hand in action (Bonda, Petrides, Ostry & Evans, 1996). In a study, participants were given 4 different visual stimuli, a figure with their hand either everything is still, their eyes would move left and right, mouth would open and close, and hand would open and close (Pelphrey, Morris, Michelich, Allison, & McCarthy, 2005). Only one stimulus was displayed at a time for 192 trials 64 times for each stimulus, appearing for 1 second. Participants had MRI scans of their brains taken during the trials. The scans showed perceiving the motion of eyes, mouth and hand activated the STS in different regions pertaining to the stimulus. Hand movements activated the inferior and posterior portions of the STS region. The STS responds specifically to face, hands (hands grasping), and body but not towards other visual stimuli (Perrett et al., n.d.). The perception of biological hand motions activates the STS more so than motion of eyes and mouth. By completing a task with one's hand and perceiving the task, on can activate the STS without partaking in a task focused on the area of STS.

Art Therapy

Aly and Turk-Browne (2015) take the finding of viewing an object to stimulate brain function to a new applied function with the use of viewing art. They used to the rationale of a stimulus will create enhanced neural activity when the stimulus is attended versus unattended to frame their study (Ungerleider, 2000). Participants were shown either a painting or virtually created room. In the painting task, participants stated whether the painting was similar or the same to the baseline painting shown. In the room task, participants were shown a virtually created room and were asked to say if the test room (altered and rotated 30 degrees in perspective from the baseline room) was the same room as the baseline room. Before and after the task, participants had an MRI scan done and during the task, they were connected to an fMRI. Participants had an increasing in brain activation after the task than before the task. There was more brain activation found in participants during the art task than in the room task. With the application of art, experimenters were able to find a connection between viewing art and brain activation.

Art has been used as a means of improving emotional health, creation of insight and nonverbal communication (Malchiodi, 2003). This has been used a therapeutic process to help those who are struggling mentally or physically. Puig and colleagues (2006) had 39 participants with either stage 1 or stage 2 breast cancer complete a 4 week long creative arts therapy program with 4 sessions lasting 60 minutes. The sessions included tasks where participants used pencils, pastels, and/or acrylic paints to freely express their emotion and psychological well-being at the time, focusing on the experience of having breast cancer. These sessions happened with a certified mental health counselor to facilitate. After the therapy sessions, participants reported having decreased tension, depression, anger and confusion with an increase in activeness. With the use of the creative arts therapy, the psychological wellbeing of participants improved.

In addition to art therapy being able to improve psychological wellbeing, studies have been done looking at the brain areas activated through art, making it a full mind and body treatment (Malchiodi, 2003). If one looks more the neural systems instead of a neural structure (Gazzaniga, Ivry, & Mangun, 2002), they will get a more holistic view on the full potential of understanding the brain. Kim and colleagues in 2008 used a case report to understand how art therapy could be applied to rehabilitate someone after having a stroke. Previous studies have shown that through art therapy, people with brain damage can improve their cognitive function, attention, memory and organization functions (David, 2000), as well as their emotional states, anger and frustration (Weinberg, 1985). This case study was of a 59-year-old woman who suffered from a stroke that caused her to have impaired motor and executive function. While she was hospitalized, she received rehabilitation therapy which included art therapy. The art therapy consisted of one-on-one 40-minute sessions twice a week, focusing on spatial perception capabilities, color recognition, shape recognition, size comparison of objects, introduction of expressed internal emption, and improved socialization. The patient was asked to freely draw (common objects, self-portraits or family members) after viewing a picture of an object, drawing with three-point perspective and making things out of clay. After the sessions there was an improvement in many cognitive functions, visual-perception, motor function, attention, construction, conceptualization, memory, and processing time. The patient also had improvement in eating, upper body dressing, bathing, walking, communication and social cognition. There was overall improvement in the patient after the art therapy treatments in their emotional, physical and cognitive health.

Jane Case-Smith (2000) used the application of simple tasks to improve a more complex skill by observing the effects of occupational therapy sessions that focused on fine motor and functional performance in children. The children received 23 therapy sessions and partook in pre and post testing of eight different fine motor and functional performance assessments. Fine motor performance components consist of in-hand manipulation (a rotation test consisting of a 1 inch peg from the pegboard, rotated 180 degrees and returned the peg into its hole, and translation test consisting of pegs picked up, moved around a palm, and then moved to the participants fingertips and placed back into the pegboard), eye-hand coordination (motor accuracy test, traced a long curved line, crossing the midline, with each hand), and visual perception (position-in-space test which examines the ability to recognize when forms have the same spatial orientation, and figure-ground, which is used to identify a hidden figure within lines and other figures). Measures of skill assessed fine motor (measured hand use, eye-hand coordination, and manual dexterity in preschool activities), and visual motor (Spatial Relations tests conducted by copying lines within a grid of dots, and Draw-A-Person which requires participants to draw themselves on a piece of paper). The performance of the children was impacted by the number of therapy session and the number of sessions with elements of play. Therapy sessions had a positive correlation on the children’s end of the year performance assessment. Focusing on elements of play, it has a positive influence on the children's performance of fine and visual motor performance. The data suggests that within the task of Draw-A-Person and eye-hand coordination, visual perception, and eye-hand skills are positively impacted (Short-DeGraff & Holan, 1992). Having the participants do the task of recreating themselves in a drawing improves their visual spatial perception without them having focus on that skill specifically.

Overview of Study

By recreating something especially one's self, there is an increase in visual spatial perception. In the study above, the area is activated through drawing a self-portrait. Visual spatial perception is located in the STS. This area of the brain can be activated through perceiving biological motion of hands. If one was to do an action with their hands like working with clay to recreate an aspect of themselves, it would activate the STS and use visual spatial perception during the process, resulting in potential increase in cognitive function more so than traditional training or not at all. Using art to improve cognitive function, participants may have faster and more efficient means of improvement as well as an outlet to express themselves or complete the meditative task in ways they would be able to do in day to day task or in traditional training.

Participants partook in a training tasks of the period of a week. The experimental group replicated their hand in clay and the control group completed crossword puzzles. It was important to the experimenter that the control group was actively involved in a training task to minimize the potential of participants knowing they are a part of the control group and not caring to do well in the testing task. The experimental group used clay for the easy usage and accessibility of the material. Clay allows the participants to partake in an action focused on moving their hands to manipulate the clay and viewing one's hands constantly during the task, which combines multiple ways of activating the STS and visuospatial perception in one action.

Methods

Participants

Participants in the current study consisted of 28 undergraduate students from Bard college (mean age= 20). Participants were randomly placed in either the experimental group (15 students [13 females, 2 males]) or the control group (13 students [6 females, 7 males]). The participants identified with various Divisions (17.9% the Arts, 5.4% Language and Literature, 50% Science Mathematics and Computing, 26.8% Social Sciences) and racial/ethnic (48% White, 11% Asian, 5% African American, 4% Middle Eastern, and 4% unidentified) backgrounds. There were no excluding demographic factors for this study.

Participants were recruited through posters that were posted around campus stating to contact the experimenter about participation and from the experimenter advertising the study. Once a person contacted the experimenter about their interest of participation in the study, they were randomized through a spreadsheet in excel into either the experimental group or the control group and assigned a day for them to come into Preston to start the experiment.

Before the experiment, participants were informed (on the procedures of the study [2 days of testing and 6 days of brain training task], benefits [potential improvement of visuospatial perception], risks [minimal to none], compensation [entered into raffle for 50 dollar gift card] and animosity of their identity in the results) and asked to sign a consent form, explaining the study and the implications to being a part of the study. For their participation, each participant was entered into a raffle for a 50-dollar gift card (see Appendix A). In the pretest questionnaire, participants gave a report of their experience and exposure to making things. They were asked

"How comfortable are you with building things?" with the answer options being "Not at all", "Kind of", and "Very", and about their level of experience with art (Expert, Advanced, Intermediate, and Beginner) and techniques used before (Sculpture, Painting and Drawing) (see Appendix B).

Procedure

Participants came into Preston on the pretest day, where they were given the informed consent form (see Appendix A), demographic form (see Appendix B) and asked to complete a computerized task (see Appendix F). Participants sat in front of a computer monitor and were asked to complete a mental rotation task. Participants were instructed on their training task for the next 6 days that would be conducted for no more than 30 minutes a day. Prior to coming to Preston, each participant was randomly assigned to either the control (crossword puzzle task) or experimental (clay task) group. After the 6 days of training, participants came back to Preston with the material they were given on the pretest day. They were asked to complete the computerized mental rotation task, debriefed on the experiment, and informed about the compensation for completion of the experiment.

Brain Training

Participants assigned to the control group were given the task of completing a crossword puzzle each day for six days. The puzzles were given to the participants on the pretest day They consisted of a 13x13 grid with an average of 62 clues for each puzzle (see Appendix E). Participants were instructed to complete the task for no more than thirty minutes a day, and they can stop if they complete the puzzle before the thirty minutes is up. Every day participants were sent emails reminding them to complete their crossword puzzle and which puzzle they would complete that day.

Participants in the experimental group were given a task of replicating one of their hands in clay for thirty minutes on each of the six training days. On the pretest day, they were given materials to create their hand (2.5 pounds of Crayola Air-Dry Clay, a wooden popsicle stick, wooden skewer, a plastic bag) and a packet (containing instructions of how to replicate hand in clay and pages to create the clay hand on) (see Appendix D). The experimenter walked the participants through the steps on how to create the clay hand on the pretest day. On each training day, participants were emailed with a reminder to complete the clay task and instructed on which hand they were recreating. Each day the hand they were recreating changed. On the odd days of the training (days 1, 3, 5), participants were instructed to recreate their right in the clay, while on the even days of the training (days 2, 4, 6), participants were instructed to recreate their left hand in clay. In addition to recreating their hand, participants in the experimental group were instructed to send a picture to the experimenter of their clay hand, their non replicated hand, and the common object of the day (day 1 a pencil, day 2 a notebook, day 3 a paperclip, day 4 a pen, day 5 a pair of scissors, day 6 a marker).

Computerized Task

For the pretest and post test, participants sat in front of a computer monitor completing a mental rotation task based on a study by Lynn and Cooper (1973). The screen displayed instructions on how the task will be done. Participants were instructed to view the screen and report fast and accurate whether an image was displayed same, pressing the key N for not mirrored, or mirrored, pressing the key Y for mirrored, to the normal orientation of the letter R or the number 2 (see Figure 1).

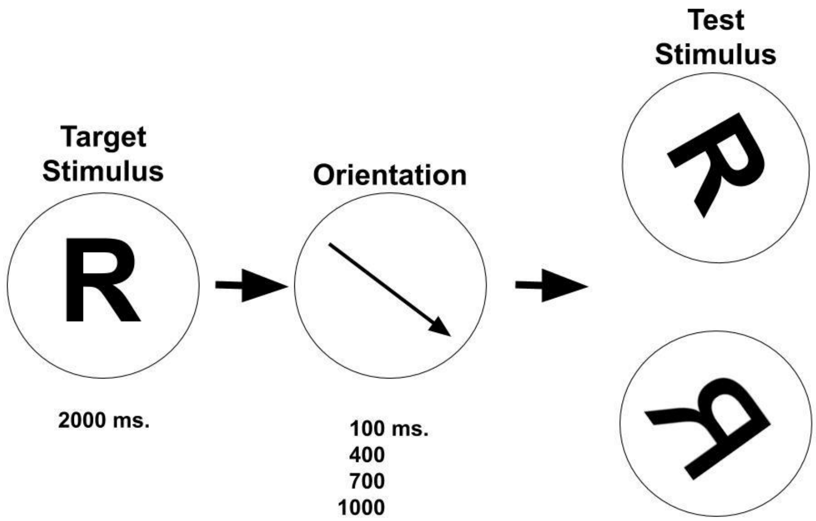

Figure 1. Stimulus shown to participants during the mental rotation task. Target stimulus was shown for 2000 ms, then the degree the test stimulus will be rotated, and finally the test stimulus was displayed rotated and mirrored or not mirrored.

The task consisted of 4 different delay time periods of either 100 ms, 400 ms, 700 ms or 1000 ms with 18 trials in each period. A prompted image of the testing stimulus and the degree the stimulus would be rotated was shown prior to the display of the testing stimulus. The testing stimulus was rotated in one of six 60-degree rotation possibilities in a randomized order between 1 and 4 times being shown in a delay time period, rotating the prompted image either 60, 120, 180, 240, 300, or 360 from the image's original orientation. The testing stimulus was shown until the participant pressed the Y (stimulus flipped from the normal orientation) or N (stimulus is shown in normal orientation) key.

Results

Participants Self Report

Before the training, participants reported on how comfortable they were with building things (7 % not at all, 61 % kind of, and 32% very), level of experience with art (54% Beginner, 36% Intermediate, 11% Advanced and 0% Expert), and techniques previously used (43% Drawing, 31% Painting, 21% Sculpting, and 5% none). The participants were comfortable with building things even though most reported average to low experience with art techniques. This can be due to the early practice of building at a young age, so the idea of building something seems more feasible than the idea of making art. Art is seen as an advanced or professional skill that most people dismiss for only named artists. Participants reported having drawn more so than the other art technique. The easy accessibility of drawing in the form of doodles or even full sketches may create a sense of higher exposure with little burden to the level of quality of the work. Sculpting and painting requires one to go out of their way to gather materials to create something, making the practice less easily available.

When the participants returned to the lab after the brain training task, they report on how well they followed the directions (46% Always, 39% Most of the time, 7% Half of the time, and 4% A little bit) and how many days they completed the study (61% 6 days, 18% 5 days, 11% 4 days, and 7% 2 days). Most of the participants in both groups followed the directions closely and completed all 6 days of the training. Participants were told that if they found an easier way to replicate their hand to feel free to use that technique, which may have led to participants reporting that they did not follow the directions closely.

Participants in the experimental clay task group also reported on how comfortable they were with clay before the experiment (11% Always, 18% Most of the time, 7% Half of the time, 11% A little bit, and 7% Not at all) and after the experiment (29% Always, 21% Most the time, and 4% Half of the time). From doing the training, participants, 53%, became more comfortable with clay than they were prior to training. 33% of participants reported to have the same level of comfort with clay, and 13% of participants reported having a decline in comfort level with clay. The increase in comfort level of using clay can be due to having to work with the material for multiple days. During the training, participants had to replicate their hand for 30 minutes which is seen as a reasonable time to complete a task whether there is interest in it or not. The decrease and stagnant improvement of comfort level with clay may be due to over stimulus or not enough stimulus with the clay. If the participants thought that the task was too hard for their skill set, there may have been a negative view of their performance with the clay. On the other hand, if the task was not stimulating enough, participants may have felt lackadaisical with the material thinking that they were not improving or working hard enough to have the feeling of improvement.

Mental Rotation

The data collected from the mental rotation task was the speed and accuracy in which the participants stated whether the stimulus was mirrored or not. Response time was calculated in milliseconds, and the accuracy was recorded into 1 (correct) or 0 (incorrect). After the tests, the means of reaction time and accuracy were calculated. The reaction time score average excluded times where the participant got the trial incorrect and if the time was too fast (<200 ms) or too slow (>2000 ms).

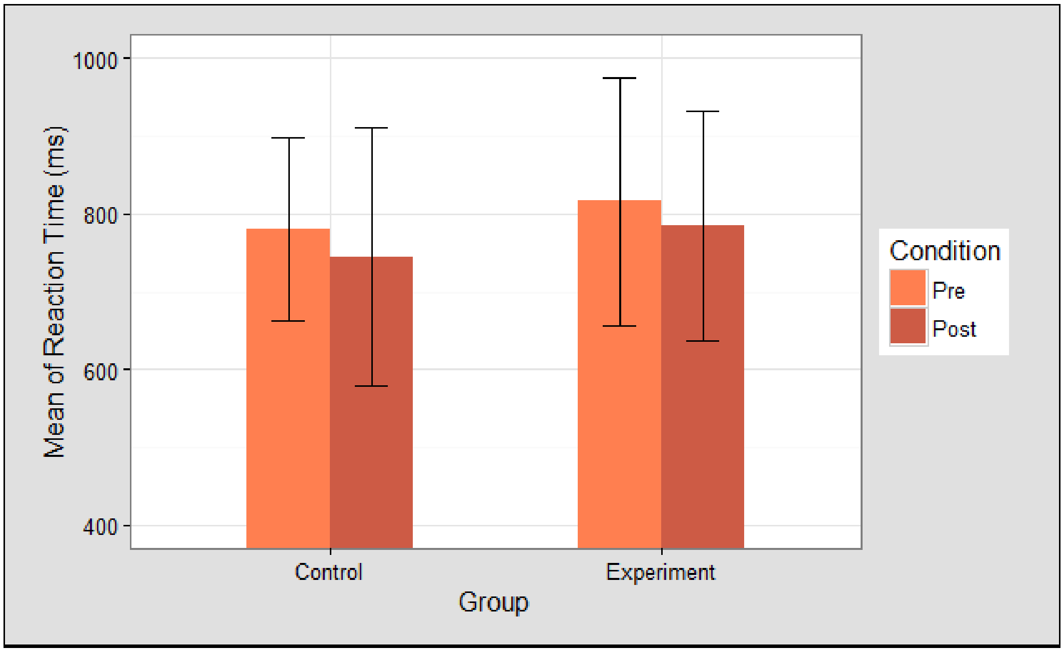

Figure 2. The mean reaction time of participants in the control and experimental group, comparing their pre and post test scores. Both groups became faster in the post test mental rotation task than in the pretest task.

Both groups within the study had decrease in their reaction time from their pretest to post test, resulting in an improvement in participant's ability to make quicker decisions about the orientation of the stimulus (Figure 2). The experimental group had slower reaction times (816 ms pretest, 785 ms post test) than the control group (780 ms pretest, 745 ms posttest). The control group (35 ms) had a greater level of improvement than the experimental group (31 ms). Participants were analyzed within a 2 group (Control, Experimental) x 2 time (Pretest, Post test) analysis and variance (ANOVA) with reaction time as a within and group as a between subject. Within the 2x2 Anova, there was no main effect found in the interaction between the group participants were assigned and the condition the test was done in regard to their reaction times (F (1,52)=0.003, p=0.957).

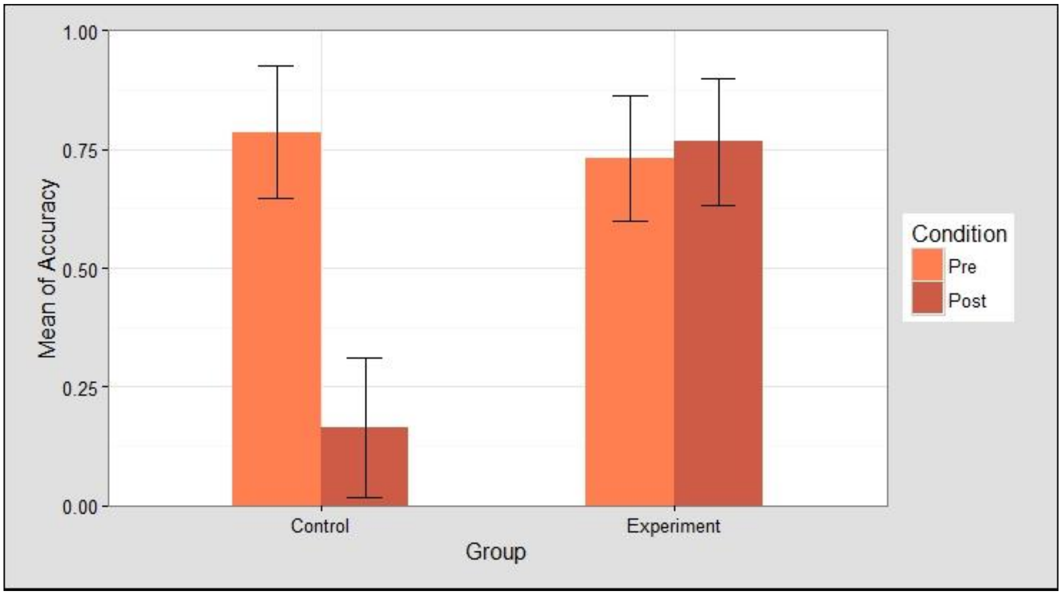

Figure 3. The mean accuracy of participants in the control and experimental group, comparing their pre and post test scores. Participants in the experimental group became more accurate, while the control group became less accurate.

The control group had a higher accuracy percentage, 79%, in the pretest than the experimental group, 73%. In the post test, the experimental group had a higher accuracy score, 77%, and more improvement from pretest to post test, 4%, than the control groups post test accuracy scores, 17%, and improvement, -62%. The control group became less accurate in the mental rotation task after the training, while the experimental group improved after training (Figure 3). Participants were analyzed within a 2 group (Control, Experimental) x 2-time (Pretest, Post test) analysis and variance (ANOVA) with accuracy as a within and group as a between subject. Within 2x2 Anova, the interaction between the group the participants were assigned and accuracy on responses within the mental rotation task is approaching significance (F (1,52)=3.288, p=0.0756)). The group that the participants are in impacted how accurate participants are on the mental rotation task. On the other hand, the interaction between the group the participants are in and the time, the mental rotation task was done has no significance on the level of accuracy they had (F (1,52)=0.089, p=0.7661). Participants accuracy may have been impacted by the group they were in, and not impacted by whether they completed the task in the pre or post test.

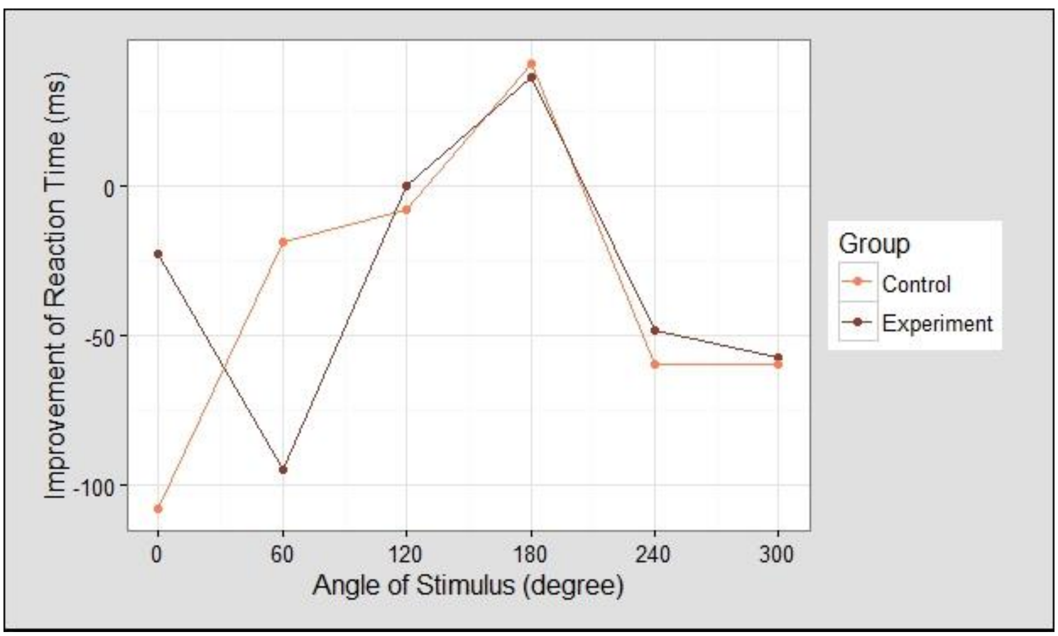

Figure 4. Improvement of the reaction time of the participants in the control and experimental group. The control group was faster in reaction time viewing the stimulus at 0 degrees, and the experimental group was faster in reaction time viewing the stimulus at 60 degrees.

When the stimulus was presented at 0 degrees rotated, the experimental group had an improvement of -22 ms which was 85 ms slower than the control group, (-107 ms). When the stimulus was presented at 60 degrees, the control group had an improvement of -18 ms which was 76 ms slower than the experimental group, -94 ms. For the rotated degrees of 120, 180, 240, and 300, the difference of improvement between groups had a mean of 4 ms. The mean improvement of the control group was -35 ms, and experimental group was -31 ms. The control group was 4 ms slower than the experimental group in overall improvement (Figure 4). There was no significant difference in the improvement in reaction time of the experimental and control group (t (5)=0.205, p=0.846, d=4.284).

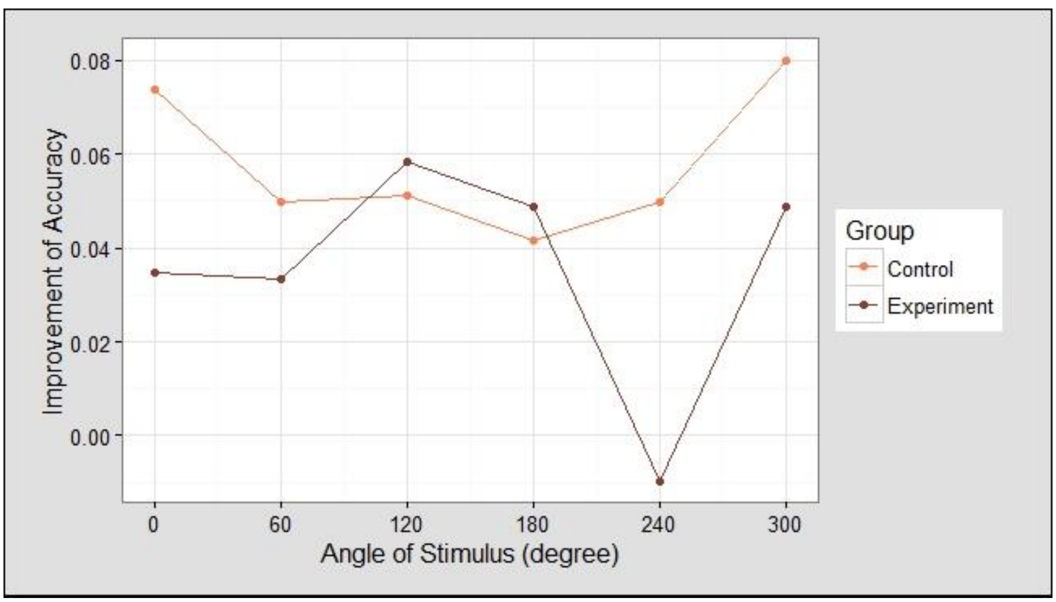

Figure 5. Improvement of accuracy from the pre to posttest of the participants in the control and experimental group. The control group had more improvement of accuracy in the mental rotation task than the experimental group.

The experimental group had an overall larger improvement in accuracy on the mental rotation task than the control group, improvement on average .02 more than the control group (Figure 5). The experimental group had a mean of .04 improvement in all degrees of stimulus. The control group had a mean of .06 improvement in all degrees of stimulus. When the stimulus appeared at 300 degrees, the control group had the most amount of improvement than any of the degrees (.08). When the stimulus appeared at 240 degrees, the experimental group had the least amount of improvement than the other degrees presented (-.01). The experimental group had more improvement on accuracy than the control group after partaking in the brain training, approaching statistical significance (t (5)=-2.043, p=0.096, d=-0.022).

The participants improvement of comfort scores in working with clay and the improvement scores of both the reaction time and accuracy scores were analyzed through Pearson's correlation. There is a positive correlation with no significance found between the improvement of comfort with clay and reaction time (r (13)=0.136, p=0.628), and comfort of clay and accuracy (r (13)=0.0428, p=0.88). The level of comfort participants has with clay does not have a high effect on the scores in the mental rotation task.

Brain Training

During each training day, the participants in the experimental group emailed the experimenter a picture of the clay replication of their hand. Once the experimenter received all the pictures from the participants, 3 random people were asked to rank the hands on how much detail is on the hand (1 No detail, 2 Some detail, 3 Detail is present, 4 Pretty detailed, 5 Completely detailed) and how similar the clay hand is to their actual hand (1 Doesn't look like a hand, 2 Looks like it could be something, 3 Looks like it could be a hand, 4 Looks like a hand, 5 Looks like their hand). The hands were randomized and given to the ranker.

The ranks of the hands were averaged between the 3 different rankers and then compared to the similarity and details of the first and last day hand to find their improvement score. The similarity of clay hand to real hand comparing the first (M=3, SD=-0.29) to last (M=2.67, SD=1.04) day hand had no significance (t (14)=1.527, p=0.149, d=0.378) in a paired t test. The details found within the clay hands comparing the first (M=3.33, SD=-0.6) and last (M=3.24, SD=0.78) day hand had no significance had (t (14)=0.340, p=0.739, d=0.089) in a paired t test.

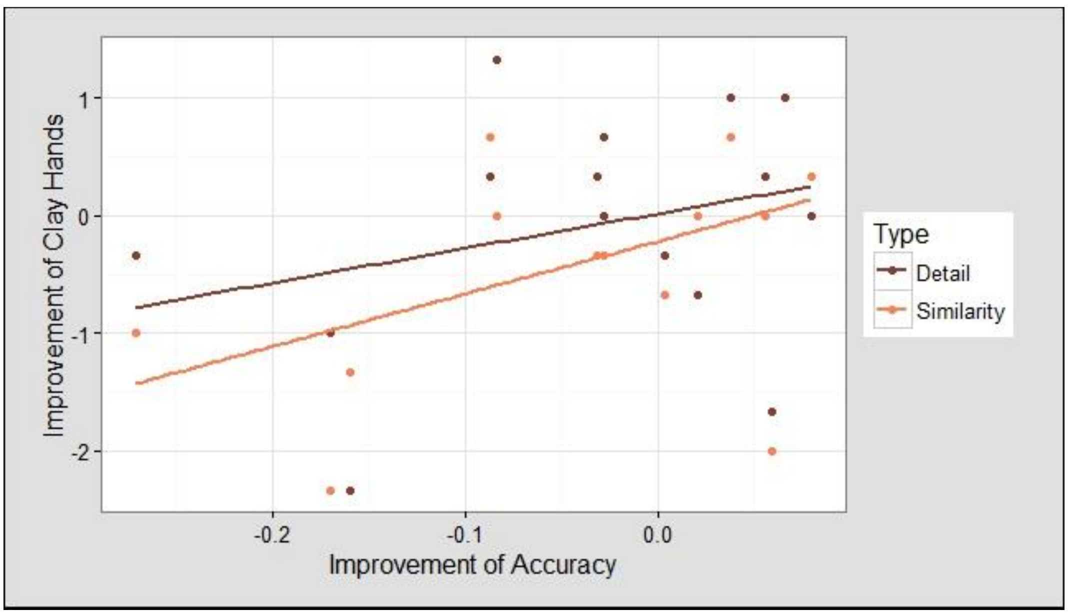

Figure 6. Improvement of clay hand in detail and similarity to their own hand in correlation of the improvement of accuracy. Positive correlation in both detail and similarity with no significance in detail and approaching significance in similarity.

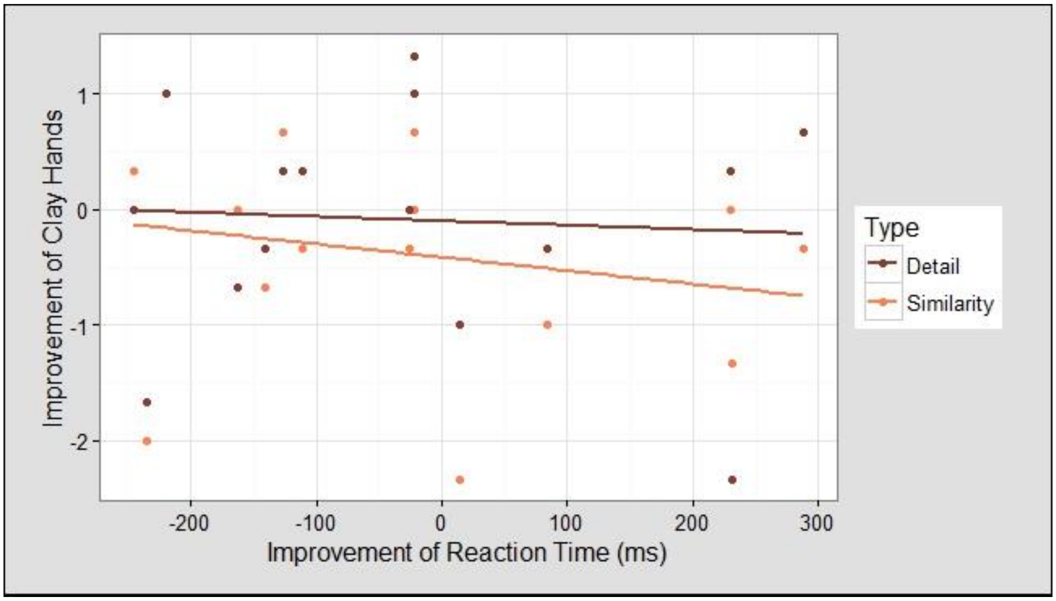

Figure 7. Improvement of clay hand in detail and similarity to their own hand in correlation of the improvement of reaction time. Negative correlation with no significance in both detail and similarity.

The question that arose was if the improvement of the hand from the first day and the last day would have a correlation effect on the improvement of reaction time and accuracy scores of each participant, using a Pearson's correlation test. There was a positive correlation with no significance between the improvement of participants accuracy score and the improvement of details in the clay hands (r (13)=0.296, p=0.285), however there was a positive correlation approaching significance in the improvement of accuracy and the improvement of similarity in the clay hands in comparison to the participants hands (r (13)=0.474, p=0.074) (Figure 6). There was a negative correlation with no significance between the improvement of participants reaction times with improvement of detail in the clay hands (r (13)=-0.064, p=0.822) and improvement of similarity in the clay hands to the participants hands (r (13)=-0.209, p=0.455) (Figure 7). The improvement of both the detail and similarity of the clay hands had positive effect on the accuracy of their scores, while it had a negative effect on their reaction time.

Discussion

The study shows that there is possible correlation between working with clay and improving cognitive function. After the training task, the participants had a positive interaction in the training and accuracy scores on the mental rotation task. The scores of reaction time were either not improved or negatively impacted by the training tasks. There was no significance found in the study, but the interaction of the participants group and accuracy score, and the correlation between the improvement of clay hands and accuracy scores were approaching significance. Through the training tasks, participants became more accurate but not faster on the mental rotation task.

Limitations

The undergraduate students who were apart of this study represent a small population of the college. Due to time and resources, collecting data from a larger and more diverse group of participants was inaccessible to the experimenter. With a longer period to run the study, the experimenter would have been able to recruit more participants by reaching out to all the communities on campus not just the ones readily available. Within in the study 2 participants dropped out lowering the population size. With a larger amount of people being recruited for the study, the dropout rate would be less detrimental to the validity of the results.

Within recruitment, participants who signed up for the study seemed to be interested in areas of applied knowledge and wanted to be a part of it. The time asked of the participants for the study was discouraging to some, making it a reason for them to not participate. This may be due to participants having no time to commit to anything more than they already have, since the study requires completion of multi day training asked of participants. The study occurred during the spring semester of the school year. During this semester, a lot of students must focus on things other than just class work. As a first year in the spring, potential participants would be starting to become active in their newly found communities which may not have been developed in their first semester. Upperclassman in the spring need to focus on moderation, internships, study abroad petitions, and even their own senior project, resulting in little time for added activities. Collecting data in the fall would have been more beneficial in collecting a larger population size and a more diverse group of participants, due to fewer distractions happening that semester.

The brain training took place at the participants own leisure in their home or wherever they wanted and at any time they found fit. Each participant may have completed the task within different environments and at different time each day, creating an inconsistent environment for them to train in. Factors of their work environment may have had an impact on their ability to focus on the training task, but there is no way for the experimenter to consider all the possible variables the participants encountered. In order to minimize the variables, participants were emailed by the experimenter everyday with instructions of the daily training task. This email was sent to the participants in either the early morning or afternoon. For the experimental group the email contained instructions of which hand they were replicating that day, and instructions of how the document the hand in order to minimize the possibility of participants taking a picture of the same clay hand or making them all on one day. However, the experimenter was not there while the hands were being produced and cannot know exactly what the participants did.

Some days the emails were sent out a bit later in the day. This may have given the participants not enough time in the day to complete the training or plan time in the day to do it. Some days participants completed the task before the email was sent out, resulting in them not having the proper directions of the day. Other times participants received the email in a timely manner, but they either did not follow the directions properly. These issues resulted in participants not having an equal amount of days for the recreation of their left and right hand, in the experimental group, and in the control group, not all the crosswords were completed. The participants in the control group and experimental group completed on average 5.4 of the 6 training days, with most participants completing all 6 days. 2 participants in the experimental group sustained injuries to their hand during the time of the brain training task. This resulted in both completing the study to the best of their abilities, but not making all 6 hand recreations.

Future Research

This study designed a training task that lasted a week. It was discussed as to whether the training should be longer or more intensive, but with the time constraints it seemed best to make the study of low intensity to increase participant number and decrease the dropout rate. Future studies should look at having higher intensity training for a longer period to see a larger effect the training has on the participants cognitive function.

Data was collected through a self-report (comfort, skill and performance on training task), mental rotation reaction time and accuracy, and collected images of clay hands. The questions within the self-report were not mirrored with the same questions asked in the pre and post test and had a likert scale from 1 to 5. For a more congruent report, the questions of “building things” and “comfortableness with clay” should have been seen in both the pre (see

Appendix B) and post (see Appendix C) test. “Building things” were asked in the pretest to all participants, and “comfortableness with clay” before and after the training was asked on the post test day. In future studies, the likert scale for them to self-report should be on and even scale with a larger range, allowing the participants to have more options in response, resulting in a more accurate report.

Future studies should use more forms of training using creative means to see how they can improve and impact cognitive function over other training methods (Puig et al., 2006). This can range from the participants working with clay in replicating something other than their hand, free creation of art, or looking at how other medians may improve cognitive function. Adding more variety in cognitive tests experimenters will see greater range of brain function and possible improvements in untargeted and untrained areas of the brain within participants. Other assessments to be used, the addition of brain imaging either while interacting with a median or during the cognitive test pre and post training to see where and when activation occurs.

Conclusion

This study looked at how art therapy interventions can be used as cognitive training. Cognitive training can be used to improve brain function all the way from cognitive decline to reducing the impact of symptoms from neurological disorders. Through actions people do, one can work out the brain just like any other muscle, even if the activity is not directly focused on improving the brain. The brain activates in multiple areas just to complete one task. By understanding where and when the brain is activated by a task, people could complete an action on anything and improve their brain function at the same time. With the incorporation of art interventions, while people are improving their brain function, they can also improve their emotional health and communicate/express in ways they may not be able to through traditional outlets. There was no significance found on how working with clay can improve visuospatial perception. Results do show that within accuracy scores of the mental rotation task, the group participants are in and the improvement they have in recreating their hand could positive and significantly impact accuracy within future studies. In a larger population size and a longer/more intense training task, cognitive training could be improved through the art intervention of working with clay, opening the gates to more possibilities to train the brain.

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Appendix A

Informed Written Consent

Project Title: Can doing Brain Training that Consists of Making a Replication of an Object Improve Visuospatial Performance?

This informed consent document contains a brief description of the purpose of this project, what procedures will be used, and the potential benefits and risks of participating. Please read this document and contact the researchers if you have any questions about the study. You should keep a copy of this form for your records.

Background: This experiment looks at how completing a visuospatial task can improve visual perception

What you will do in this study: If you agree and continue you with this study, you will be asked to partake in a six-day training task that will take no more than 30 minutes of your time each day. There will be a task for each day assigned prior to the experiment.

Risks and Benefits: You will be exposed to minimal risks during this experiment and may receive the benefit of improving the function of your visuospatial perception.

Compensation: In exchange for your participation, you will be entered into a raffle for a 50-dollar gift card, once the experiment is completed and all papers are completed/turned in.

Your rights as a participant. Your participation in the experiment is completely voluntary. You can stop the experiment at any time and email Rachael Rice informing that you will no longer be a participant, no questions will be asked about your discontinuation of the experiment. If you choose to not continue the study, you will be taken out of the raffle for the gift card and receive no compensation for the experiment. In order to receive compensation, you must complete the experiment, and return to Preston at the end of the experiment.

Confidentiality. Each participant will be assigned an ID number. All your information and papers will be stored in a folder in a locked cabinet in Preston. The experimenter, Rachael Rice, will be the only one who has access to your information, including what number you got assigned.

The final published version of this research will be permanently and publicly available as a Senior Project at the Stevenson Library of Bard College

You must be 18 years or older to participate in this study. By continuing this survey, I affirm that I have read and understood the above information and voluntarily agree to participate in the research project described above. I accept the risks of harm described as well as the benefits described above. By continuing this survey, I acknowledge that I am 18 years or above.

____
Participant Print Name Here

____________________________________ ________________
Participant Sign here Date

___________________________________ ________________
Experimenter Sign here Date

The experimenter will give you more information regarding the study after it has ended.
If you have questions or would like to know more about this subject or the experiment, please contact the primary researcher, Rachael Rice at rr2816@bard.edu. If you have questions about the Bard Psychology Program, you may contact Associate Professor Thomas Hutcheon, advisor to this project, a, at thutcheo@bard.edu. If you have questions or concerns about your rights as a participant, please contact the Bard College Institutional Review Board at irb@bard.edu

Appendix B

Demographics

ID Number____________________
Major: _______________________
Year at Bard: __________________
Age: __________

Gender: _______________
Race/Ethnicity (select all that apply):
O Asian O Black/African American O White/Caucasian
O Hispanic/Latino O Native American O Pacific Islander
O Other: _______

How comfortable are you with building things?:
o Not at all o kind of o very
Level of Experience with Art:
o Beginner o Intermediate o Advanced o Expert
Technique Used Before:
o Drawing o Painting o Sculpting

Contact Information :
Email : _________________
Number : ________________

Appendix C

Post- Test Questionnaire

How well did you follow the directions of the study?

_Not at all _A little bit _Half of the time _Most of the time _Always

How many days of the week did you do the training?

How comfortable did you feel about working with clay before the experiment?

_Not at all _A little bit _Half of the time _Most of the time _Always

How comfortable do you feel about working with clay after the experiment?

_Not at all _A little bit _Half of the time _Most of the time _Always

Appendix D

Experimental Group Clay Task Experiment

1. Lay the hand opposite of the hand that is designated to sculpt on the designated blank sheet of paper to the day of testing it is.
    a. Once hand is on paper trace the hand with fingers together and thumb sticking out. Trace the hand all the down to the wrist and off the page

2. Make five balls of clay the size of your palm equal in size
    1. Roll or squeeze each ball of clay into ropes within your hands or on the table; Make the rope into equal width no longer that

3. Lay three of the ropes on the diagram of your hand where the three middle fingers lay
    1. Lay three of the ropes on the diagram of your hand where the three middle fingers lay

4. Push the clay back and forth to make the lines between the ropes go away
    1. Start at the line of the bottom finger crease and move the clay all the way to the bottom of the hand, including the wrist

5. Lay another rope where the picky of your hand is located
    1. Where your wrist starts; lay the picky rope on top of the closest rope

6. Same as 4 push the clay back and forth getting rid of the line, starting at the line right below the fingers all the way down through the wrist

7. Lay the fifth rope where the thumb of the hand is drawn
    1. When the rope meets the hand curve the rope to follow the outside shape of the hand until it meets the wrist, then the rope will follow the arm
    2. Move the clay back and forth similar to 4 and 6 so there is no line between the rope and hand

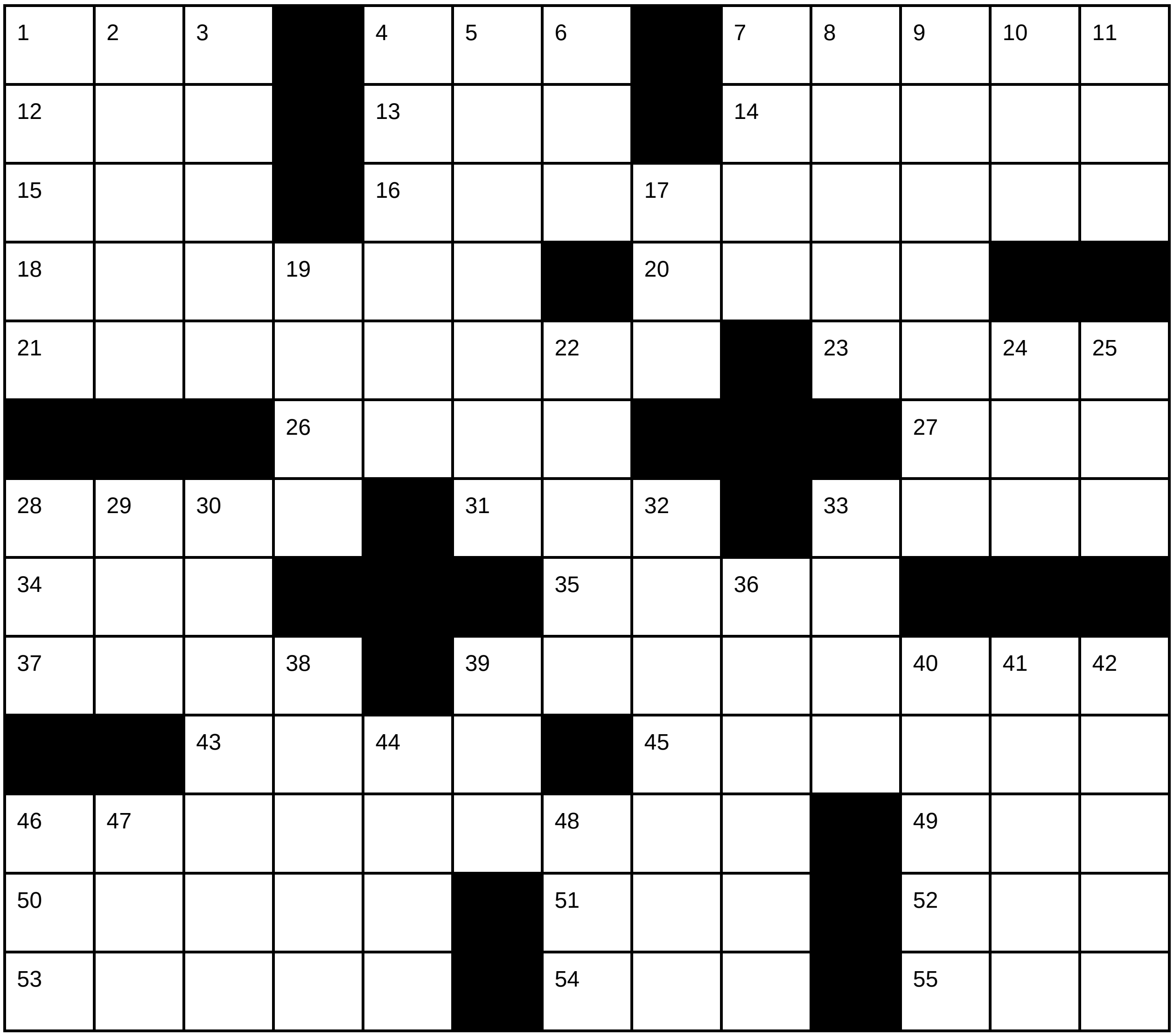
8. Make a small rope and lay the line between the palm and fingers was made
    1. Move the clay back and forth so there are no lines
    2. Make a ball of clay and lay it between the thumb rope and the palm
    3. Move the clay back and forth so there is no line
    4. These pieces are for the muscles of the hand

9. Add details to the hand to make it look like yours including palm and finger lines, more mass to hand and wrist
    1. If you think there is nothing more to add think of these questions
    2. Is your hand really that big or small?
    3. Are those where your hand lines lie?
    4. Try to build the hand off the paper to make it more 3 dimensional

Appendix E

Control Group Paper and Pencil Task

Puzzle Day 1



Puzzle Day 1 Clues

Across

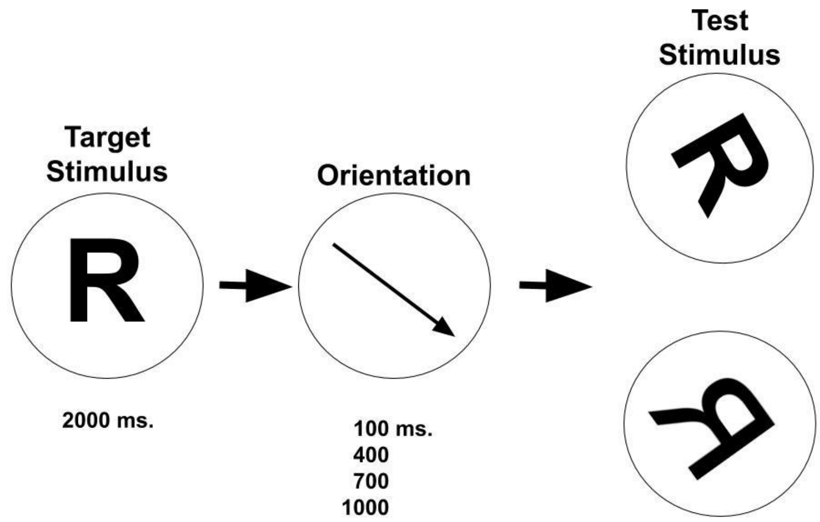
1 That Bot
4. Dry as wine
7. Book of maps
12. Conceit
13. Before, to Shakespeare
14. Part
15. "____ That Jazz"
16. Work together
18. Uses of oven
20. Plow-pulling animals
21. Turtle
23. Hearing-impaired
26. Treat pleats
27. RR terminal
28. Glide
31. Yule drink
33. Big Dipper component
34. Possesses
35. Songstress ____ McEntire
37. Clapton or Idle
39. Representative
43. Facial features
45. "Lawrence of _____"
46. Get rid of
49. CIA employer (abbr.)
50. Flax product
51. Drill part
52. Summer shirt
53. Come together
54. Printers' measure
55. Misjudge

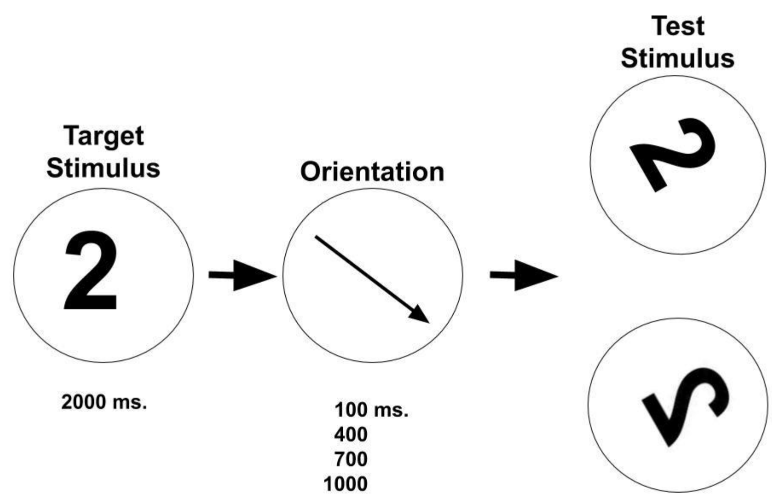
Down

1 Valentine Symbol
2. Icehouse
3. Back tooth
4. Zone
5. Wearing down
6. Corporate VIP
7. Highest point
8.Tuckered out
9. Thinnest
10. Play segment
11. Visit
17. "The Raven" poet
19. Agitate
22. Night sound
24. ______ moment's notice (2 words)
25. Remote
28. That girl
29. Rowing tool
30. Foolish
32. Molded dessert
33. Heroic narrative
36. Flat caps
38.Tailed celestial body
39. Lion's lair
40. Decrease
41. Golfer ____Woods
42. Consumer
44. Misdeeds
46. Shade tree
47. Untruth
48. Lincoln, informally

Appendix F

Mental Rotation Task





Appendix G

Debrief Statement

Can doing Brain Training that Consists of Making a Replication of an Object Improve Visuospatial Performance?

Important Information: This study looked at how completing a hands-on task can improve visuospatial perception. There are 2 groups the experimental group, who replicated their own hands in clay, and the control group, who complete a paper and pencil puzzle. It is hypothesized that doing an object orientation task like replicating one's own hand will improve visuospatial perception.

If you have any questions about your actual performance or would like to know more about this subject, please feel free to contact the experimenter, Rachael Rice at rr2816@bard.edu.

If you have any questions about the Bard Psychology Program, you can reach Associate Professor Thomas Hutcheon, advisor of this project, at thutcheon@bard.edu.

If you have questions or concerns about your rights as a research participant, please contact the Bard College Institutional Review Board at irb@bard.edu.

Appendix H

Recruitment Poster

Appendix I

IRB Proposal

SECTION 1: *Contact Information*

Rachael Rice (770) 876-1550, rr2816@bard.edu, Psychology, Undergrad

Thomas Hutcheon, thutcheon@bard.edu

SECTION 2: *External Funding*

No, funding will only be coming from the Bard Psychology Department.

SECTION 3: *Dates of Project*

Start Date: November 23, 2018

End Date: May 1, 2019

SECTION 4: *Description of Project*

Can doing Brain Training that Consists of Making a Replication of an Object Improve Visuospatial Performance?

Research Question(s):

Cognitive training is useful for improving brain function. There are many ways this training can be done. Traditional training has been done through word list for memory. Nowadays there are more engaging activities one can do, for example, children can play video games to increase their attention and short-term memory, thus reducing the symptoms for ADHD and decreasing their need to be on medication. In other studies, music therapy is used to help improve the development of speech through clapping and rhythm in nonverbal autistic children.

The level of engagement of participants has increased their motivation and willingness to improve. With some demographics like children, elderly, and mentally ill, maintaining engagement levels can be difficult, and should use more innovative brain training then the tradition word list.

This study looks at how recreating a 3-dimensional object into the moldable material will improve Visuospatial Perception. This study will consist of 30 participants who will undergo 6 days of training mental pre and post-test day, resulting in 8 days. The experimental group will be replicating their hands in clay to work the visuospatial area, while the control group is doing paper and pencils puzzles.

SECTION 5: *Specific Populations*

No specific populations will be targeted

SECTION 6: *Estimated Number of Participants*

30 participants: 15 participants in control group, 15 participants in experimental group

SECTION 7: *Risks and Benefits*

There are minimal risks that the participants will be exposed to in this experiment. The participants will take part in a simple visual task on the computer and work with clay/complete a paper and pencil puzzle, Participants will benefit from the possibility of their visuospatial perception being improved.

SECTION 8: *Consent Form*

Participants will provide written consent indicating that they are at least 18 years of age, understand the risks/benefits of the study and that they agree to participate. See Appendix A

SECTION 9: *Confidentiality Procedure*

All participants will receive an ID number at the beginning of the experiment. This number will be associated with all the data collected from the participant. Information of the participants including their contact information and demographics will be kept securely in a locked cabinet in Preston Hall or a password locked computer in Preston Hall. Only the experimenter, Rachael Rice, will have access to participants information and all papers in the cabinet.

SECTION 10: *Deception*

There is no deception in the experiment.

SECTION 11: *Debriefing Statement*

Please see Appendix G for debriefing statement

SECTION 12: *Certification of Completion in the Ethical Treatment of Human Research Participants*

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Rachael Rice** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 11/04/2016.

Certification Number: 2172588.

SECTION 13: *Recruitment Procedure*

Participants will be recruited through tabling in the Campus Center or Kline Commons, posting on social forums and flyers put around campus, Appendix H. During these recruiting opportunities, prospective participants will be informed that “This study will focus on your Visual Perception abilities and how they can be improved through daily training of the brain. The study requires participants to be able to participate for 8 straight days and complete a training task that will take no longer than 30 minutes to complete for most of the days. Every participant's name will be put in a raffle for a 50-dollar gift card.”

SECTION 14: *Procedure*

Participants will come in on day one to Preston. Each participant will be assigned randomly to either the experiment or control group, give written consent and be given the testing prompts for the group they have been assigned. Both groups of participants will do a mental rotation task for the pretest, Appendix F. On the pretest day, the experimental group will receive walk-through instructions on how to replicate their hand into the clay. They will be given material to make the replications in their own space, including a clay, simple tools (a popsicle stick and wooden skewer), and a packet of the steps to replicate, Appendix D. The control group will be given a paper and pencil puzzle to complete on the pretest day, Appendix E. They will also receive a packet of paper and pencil puzzles to complete each day of the testing phase. During the training phase, the experiment group will be recreating their hand in clay for 30 minutes each day. They will receive an email about which hand they are making out of clay and what object they will be taking a picture with. The object for each training day will be as followed: day 1 a pencil, day 2 a notebook, day 3 a paperclip, day 4 a pen, day 5 a pair of scissors, day 6 a marker. Every odd day of the training phase the participants will be making their non-dominant hand and on the even days, the participants will be making the dominant hand. After the 30 minutes is over, participants will send the picture of the hand next to one of their hands with the assigned object in the picture to Rachael Rice, rr2816@bard.edu. This is to ensure that the participants are following the experimental instructions. The control group will be completing the crossword designated for each day of the testing phase, in the packet they received on day 1.

After the testing phase, participants will return to Preston where they will return testing material, complete mental rotation post-test, and post-training questionnaire and demographics sheet Appendix B and C. All participants will be debriefed and given further instructions about the raffle before leaving Preston Appendix G.

Appendix J

IRB Approval

Bard College Institutional Review Board

Date: November 20, 2018

To: Rachael Rice (rr2816@bard.edu)
Cc: Thomas Hutcheon (thutcheon@bard.edu)
From: Sanjay DeSilva, IRB Chair

Re: Can doing Brain Training that Consists of Making a Replication of an Object Improve Visuospatial Performance?

DECISION: APPROVED

Dear Rachael,

The Bard Institutional Review Board reviewed your proposal under expedited category 7,

(i) Research activities that present no more than minimal risk to human subjects, and

(ii) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Your proposal is approved through November 20, 2019. Your case number is 2018NOV20-RIC.

We have one suggestion regarding a possibility for minor discomfort in the demographic part of the survey. Two questions are listed for race and ethnicity and no options are given. Some respondents may not have an ethnic identity that is distinct from their racial identity and may want to leave one or the other blank. We recommend that this option is clarified in the survey form.

Please notify the IRB if your methodology changes or unexpected events arise.

We wish you the best of luck with your research.

Sanjay DeSilva
desilva@bard.edu
IRB Chair