The Effect of Acute, Moderate-Intensity Exercise on Creative Thinking in Children of Varying Body Mass Percentiles

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Abstract

Creativity is an important area of study within the field of cognition that includes the mental processes which influence the daily lives of individuals and their problem-solving skills. Physical activity, which combats the risks associated with obesity, influences a wide array of cognitive processes and has the potential to influence creative thinking. However, to date, there is no evidence associating acute bouts of moderate-intensity physical activity and creative thinking in children. Based on previous research conducted in adults, we hypothesized that acute physical activity, delivered via 20 minutes of treadmill walking, would improve performance on the Gilford Alternative Uses Task, a measure of creative thinking. However, contrary to our hypothesis there were no significant differences observed when comparing acute exercise to a control condition consisting of seated rest.

Key Words: acute, moderate-intensity, aerobic physical activity, creative thinking, obesity, GAU

Introduction

Physical Activity & Obesity Trends in American Children

The 2018 Physical Activity Guidelines for Americans recommends that children participate in a minimum of one hour of moderate-to-vigorous physical activity each day. Physical activity aids in improving mood and energy levels, managing stress, maintaining strength and stamina, minimizing physical health risks, and combating the effects of aging (1). Unfortunately, according to the Center for Disease Control and Prevention (CDC), only 21.6% of children and adolescents meet this recommendation, for five rather than the recommended seven days a week (2). This behavioral trend is further revealed in today’s childhood obesity epidemic. There has been a significant, inverse relationship established between the time and intensity of physical activity with Body Mass Index (BMI) (3). BMI is an estimate of body fat that is calculated by a person’s weight in kilograms divided by the square of their height in meters (4). Obesity in children is defined by a BMI that falls above the 95th percentile, while overweight is the 85th to
95th percentile, and these percentiles are derived from normed data based on age and sex. The obesity rate has tripled since the 1970’s, with one in five children now considered obese. According to the CDC, childhood obesity has been linked to chronic health conditions, social isolationism, depression, lower levels of self-esteem, and the likelihood of having obesity as an adult, which is associated with even greater health risks (5). Obesity has also been found to have adverse cognitive effects in children. Li et al. (2012) observed a correlation between increased body weight and decreased visuospatial organization and general mental ability (6). Other studies have linked obesity to longer reaction times, decreased cognitive control network modulation, overall cognitive functioning, as well as poorer academic achievement in measures of reading and mathematics (7,8,9).

The Impact of Physical Activity

One potential way to combat the effect of obesity on cognition is with physical activity (10). Several studies report on the benefits of physical activity participation for cognitive processes in the areas of memory, attention, and cognitive control. Specifically, Hillman et al. (2009) found an improvement in children’s cognitive control and academic achievement following twenty minutes of walking on a treadmill at sixty percent of the participant’s maximum heart rate (11). Additionally, Drollette et al. (2014) has shown that the same exercise paradigm minimized individual differences in inhibitory control capacity, by benefiting the lowest performers the most (12). Inhibitory control is the ability to suppress a dominant, impulsive response and is a key element of attention capacity due to its role in filtering out unwanted information. Inhibitory control also plays an important role in academic achievement. Academic achievement encompasses standardized test scores, classroom behavior, learning skills, and overall knowledge attainability. These characteristics have been linked to lifelong constructive group behaviors such as cooperation, collaboration, and risk-taking when established during early elementary grades (13) (14). Other areas of childhood cognition are also influenced by exercise; Ludyga et al. (2018) found children who participated in acute exercise had higher cognitive flexibility compared to control groups, while Pesce et al. (2009) determined that an acute bout of moderate-intensity exercise improved memory storage (9,15). Furthermore, Kantomaa et al. (2012) investigated different weight categories, and revealed that obesity and
physical activity had opposing relationships on childhood motor function and academic performance (16).

Creativity

Creativity is a component of cognition that may be influenced by physical activity (17, 18, 19). However, creativity has yet to be conceptually well understood, studied, or even defined in adults and children. The modern definition of creativity is the generation of both novel and useful ideas, meaning creativity expands beyond stereotyped creative tasks like writing, music composition, and art (20). The smaller decisions of daily life, such as avoiding traffic on the commute home, thinking of a clever gift, how to substitute ingredients in a recipe, and other problem-solving tasks are also influenced by creativity as they recruit novel and useful thoughts. Conceptually, creativity is often expressed through a thought process known as divergent thinking, which is the exploration of all possible outcomes for open-ended prompts or questions. Divergent thinking focuses on novel limitless solutions and is defined by its spontaneous, free-flowing nature of thought (21).

In examining the current creativity literature, the majority of studies thus far have focus on adult populations. Oppezzo and Schwartz (2014) completed a thorough investigation on how an acute bout of moderate-intensity walking on a treadmill improves divergent thinking in adults through four experimental designs (17). Researchers compared a condition that involved walking followed by sitting to a condition that involved sitting followed by walking and found improved responses after walking that persisted following rest. The first experiment analyzed aerobic effects of walking on divergent thinking and convergent thinking tasks, finding significant improvements on Guilford Alternative Uses (GAU) scores, a measure of creativity. Experiment 2 controlled for GAU score improvement due to practice effects and still observed improvements following walking (17). Nonetheless, only a few studies have analyzed the influence of physical activity on creativity in children. In 6-7-year-old children, Jones, Taylor, and Sutton (2010) observed a positive correlation between creativity, measured as a tissue-paper collage, and unstructured playtime, defined as playing with play dough rather than completing a handwriting exercise. Children who spent more time in unstructured play had higher creativity scores (18). This type of unstructured play has been correlated with both cardiovascular and physical fitness
Further examination of the role of physical activity and creativity in children revealed only one study. Herman-Tofler and Tuckman (1998) found that aerobic exercise programs, compared to traditional third grade physical education programs, improved performances on the Torrance’s Tests of Creative Thinking (19). Students participated in three sessions a week for eight weeks. While there is a paucity of research examining the long-term effects of chronic physical activity on creativity in children, there is no research that has examined the effects of a single, acute bout of moderate exercise on creativity in children. In addition, no studies have examined the role of weight status on creativity outcomes in children, which is of considerable interest based on the cognitive effects of obesity.

Purpose and Hypothesis

Accordingly, based on the extant creativity literature, the present research investigated the temporal effects of acute, moderate-intensity exercise on creativity in children of different weight categories. Based on previous literature, (Oppezzo & Schwartz, 2014; Kantomaa et al. 2012), it was hypothesized that (1) creative thinking would improve following acute exercise and (2) that obese children would exhibit greater improvements in creative thinking relative to their normal weight peers.
Methods

This study was approved by the Northeastern University IRB under protocol #17-0613, “The Role of Exercise and Body Weight on Brain Function” that examines the effects of acute exercise on cognition in 8-10-year-old normal weight and obese children.

Participants

Twenty-five children from the Greater Boston area were included in this study, and their demographic information is presented in Table 1. Recruitment included social media posting, flyers, and mailing lists in the Greater Boston area. Children visited the Center for Cognitive & Brain Health on three separate days. After providing consent on their initial visit, and completing a demographic and health history battery, participants’ body composition was measured via a dual energy x-ray absorptiometry (DEXA) scan. DEXA scan decompose body mass into fat, bone, and lean tissues through x-ray imaging (23). Of particular interest, the DEXA scan measures whole body fat percentage. The participants then completed the Kaufman Brief Intelligence Test-2 (KBIT2), which includes verbal and nonverbal components as a measure of intelligence (IQ). Lastly, participants were given a practice version of the Gilford Alternative Uses task (GAU) to provide task exposure.

Cardiorespiratory Fitness Assessment

Participants performed a maximal oxygen consumption exercise test, known as the VO_{2max} test at the completion of their first visit. VO_{2max} test measures breathe by breathe oxygen inhalation while a participant runs on a treadmill. During a VO_{2max} test, the treadmill speed remains at a constant pace with incline increases of 2.5% every two minutes until maximal exertion is achieved (24). A relative VO_{2max} score is achieved upon meeting at least two of four criteria: 1. Maximal heart rate exceeds 185 bpm (24), 2. Oxygen consumption plateaus, 3. The Respiratory Exchange Ration equals or exceeds a value of 1.0 (25), and 4. A participant gives a subjective, numeric response of eight or higher to the children’s OMNI scale, a rating of perceived exertion scale that ranges from 0 to 10 (26). An individual’s peak oxygen consumption is measured in mL/kg/min. In addition, using body composition obtained from the DEXA scan, participants’ fat-free VO_{2max} was also calculated as mL/ kg (lean)/ min. Fat-free VO_{2max} has
been shown to improve the validity of aerobic fitness capabilities in children of differing weight status (9). Demographic and fitness data is presented in Table 1.

Table 1: Participant Demographics and Fitness Data (Mean ± Standard Error)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total Participants n=25</th>
<th>Normal Weight Participants n=19</th>
<th>Overweight &amp; Obese Participants n=6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>11 females, 14 males</td>
<td>8 females, 11 males</td>
<td>3 females, 3 males</td>
</tr>
<tr>
<td>Age (years)</td>
<td>9.46 ± 0.16</td>
<td>9.32 ± 0.19</td>
<td>9.89 ± 0.15</td>
</tr>
<tr>
<td>BMI</td>
<td>17.72 ± 0.77</td>
<td>15.93 ± 0.23</td>
<td>23.40 ± 1.67</td>
</tr>
<tr>
<td>VO₂ max (mL/kg/min)</td>
<td>45.08 ± 1.65</td>
<td>48.07 ± 1.55</td>
<td>35.61 ± 1.88</td>
</tr>
<tr>
<td>VO₂ Fat-Free (mL/kg(lean)/min)</td>
<td>64.08 ± 1.75</td>
<td>64.89 ± 2.09</td>
<td>61.67 ± 3.24</td>
</tr>
<tr>
<td>Max Heart Rate (bpm)</td>
<td>190.64 ± 2.28</td>
<td>188.58 ± 2.46</td>
<td>197.17 ± 4.83</td>
</tr>
<tr>
<td>Whole Body Fat (%)</td>
<td>26.18 ± 1.73</td>
<td>22.93 ± 1.05</td>
<td>35.96 ± 4.29</td>
</tr>
<tr>
<td>SES (mother’s education)</td>
<td>4.43 ± 0.14</td>
<td>4.50 ± 0.15</td>
<td>4.20 ± 0.37</td>
</tr>
<tr>
<td>IQ</td>
<td>116.23 ± 3.17</td>
<td>114.65 ± 3.20</td>
<td>121.60 ± 9.16</td>
</tr>
</tbody>
</table>

SES: Socioeconomic Status
VO₂ max: maximal oxygen consumption
VO₂ Fat Free: accounts for absolute VO₂ with respect to lean mass

Intervention Protocol

This study employed a within-subjects crossover design, whereby each participant completed two intervention sessions in a randomized, counterbalanced design on two different days. The interventions consisted of 20 minutes of seated rest which included reading and 20 minutes of acute aerobic treadmill walking. Heart rate was measured throughout each session with a Garmin heart rate chest monitor, with measurements taken every minute during the intervention. The walking intervention was 60-70% of each individual’s heart rate maximum (Table 2), as determined during the VO₂ max test. Participant’s Rate of Perceived Exertion was measured throughout the intervention. Following the intervention, a randomized version of the GAU task was administered. At the completion of all sessions, participants were compensated $15/hour of their time spent in the lab.
Assessing Divergent Thinking

Creativity is a cognitive process and results in the establishment of a creative product: solutions that are both novel and appropriate (20). Creativity is often measured through one of three types of assessments: divergent thinking assessments, self-assessments, and artistic assessments; however, the most common measurement is the divergent thinking assessment, the Gilford Alternative Uses (GAU) task (27). Upon completion of each intervention, children completed the Gilford Alternative Uses (GAU) task. The GAU was conducted by presenting a participant with an everyday object such as water bottle and asking the individual to provide as many alternate uses (e.g., playing catch, planting a flower in it) for the object that he or she could generate. During each of the three sessions, participants were given the same instructions for the task, and were allowed one-minute to practice on an object that would not be tested later. The instructions stated the importance of giving answers that were detailed, differing, and appropriate. The actual task followed the practice, which contained three different objects, with spaces to write creative uses underneath each object. The participant was instructed to write down as many creative uses for each of the three objects as possible, within a six-minute time span. Participants were free to move from object to object within the six minutes. The GAU grading process was conducted after the completion of all twenty-five participants, in order to appropriately score the originality components of the task. The grading process utilized standardized evaluation methods presented by the MindGarden Manual (originally designed by Wilson, Guilford, Christensen & Lewis, 1954) that was used in the Oppezzo and Schwartz (2014) study (28, 29).

Creativity Grading

GAU responses were evaluated based on five components: fluency, acceptability, flexibility, elaboration, and originality. Each response was given one point for the component of fluency to assess number of responses. Responses were then filtered for acceptability: whether or not the use provided was feasible. Answers deemed acceptable were further evaluated based for originality, flexibility, and elaboration. Originality assessed uniqueness of answers, which was determined by examining the percentage of a certain answer relative to total answers for an object across participants. Answers provided five percent of the time were given one point, while answers that were provided one percent of the time were given two points. The flexibility
component assessed category differences, whereby each answer that was dissimilar to the rest of the sample was given one point. For example, in the prompt “newspaper” “to crush bugs” and “to swat a fly away” fell within the same category, therefore, only one answer was given the point for flexibility. The final grading component was elaboration. Participants received zero, one, or two points depending on the level of detail provided in the answer. The scores were then summed across both total answers and components of scoring to give a total score for that version. Three research assistants graded the subjective components of the test: elaboration, acceptability, and flexibility in order to minimize grading bias. When scores differed between the three research assistants, the mode for each answer was used in the final statistical analysis. Because the elaboration component could have three different answers, the average score per word was used in the analyses.

Statistical Analysis

Creativity responses for the GAU were analyzed using a 2 (Weight group: normal weight (NW), combined overweight and obese (OB/OW)) X 2 (Intervention: rest, exercise)) repeated measures analysis of variances (ANOVA). Additionally, based on our hypotheses, paired t-tests for each of the creativity responses were conducted separately as planned comparisons, considering only the effect of intervention. Finally, correlations between creativity (six GAU scoring components) and physiological measures (BMI, VO₂Max and VO₂FatFree) were conducted. All statistical analyses were conducted using a significance level of $p = .05$. 
Results

Repeated measures ANOVA revealed no significant effects of group at the .05 level for the six scoring components: Fluency $F(1,1)= 0.01 p=0.95 \eta^2=.000$, Acceptability $F(1,1)= 0.04 p=.85 \eta^2=.002$, Flexibility $F(1,1)= 0.06 p=0.80 \eta^2=.003$, Elaboration $F(1,1)= 1.38 p=.25 \eta^2=.06$, Originality $F(1,1)= 0.18 p=0.68 \eta^2=.008$, and Total Creativity Score $F(1,1)= 0.16 p=.69 \eta^2=.007$. Additionally, there was no significant interaction effects between creativity scores and intervention; Fluency $F(1,1)= 0.02 p=0.94 \eta^2=.001$, Acceptability $F(1,1)= 0.28 p=0.60 \eta^2=.012$, Flexibility $F(1,1)= 0.04 p=0.85 \eta^2=.002$, Elaboration $F(1,1)= 0.001 p=0.97 \eta^2=.000$, Originality $F(1,1)= 0.02 p=0.89 \eta^2=.001$, and Total Creativity Score $F(1,1)= 0.27 p=0.61 \eta^2=.012$. Paired samples t-test revealed no significant effect of intervention at the .05 level for the six scoring components: Fluency $t(22)=-0.76 p=0.46$, Acceptability $t(22)=-1.23 p=0.23$, Flexibility $t(22)=-0.53 p=0.60$, Elaboration $t(22)=0.21 p=0.84$, Originality $t(22)=-1.53 p=0.14$, and Total Creativity Score $t(22)=-0.06 p=0.95$. Correlation values between creativity and physiological measures are listed in Table 2. Pearson’s correlations revealed a significant relationship between Total GAU creativity scores during rest and Fat-free VO$_2$max (Pearson’s $r=0.40, p=0.050$); however, no other significant relationships were found. Figure 2 provides mean ± SE values for each scoring component for each weight group, split by intervention and scoring components.

Figure 1. Mean percentage of heart rate max across participants throughout the intervention period. Heart rate was further categorized per intervention condition and weight classification groups, determined by BMI percentile.
Figure 2. Mean & Standard Error for GAU scoring components for all participants, which are further divided by weight classification groups (NW, OW/OB), determined by BMI percentile. (a) Fluency defined by total answers, (b) Acceptability defined by appropriateness, (c) Flexibility defined by categorical use, (d) Elaboration defined by level of detail, (e) Originality defined by uniqueness of answer compared to all prompt answers, (f) Total GAU score defined by sum of all grading components per prompt.
Table 2
Correlations between Variables. Pearson Correlation Coefficient values were calculated for all demographic against GAU grading variables.

<table>
<thead>
<tr>
<th>GAU Grading Component</th>
<th>BMI%</th>
<th>Relative VO₂max</th>
<th>Fat-Free VO₂max</th>
<th>Whole Body %Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest Intervention</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluency</td>
<td>-0.025</td>
<td>0.297</td>
<td>0.282</td>
<td>-0.160</td>
</tr>
<tr>
<td>Acceptability</td>
<td>-0.006</td>
<td>0.336</td>
<td>0.307</td>
<td>-0.198</td>
</tr>
<tr>
<td>Flexibility</td>
<td>-0.026</td>
<td>0.322</td>
<td>0.339</td>
<td>-0.175</td>
</tr>
<tr>
<td>Elaboration</td>
<td>0.171</td>
<td>0.088</td>
<td>0.221</td>
<td>0.072</td>
</tr>
<tr>
<td>Originality</td>
<td>0.080</td>
<td>0.281</td>
<td>0.270</td>
<td>-0.175</td>
</tr>
<tr>
<td>Total Score</td>
<td>0.084</td>
<td>0.336</td>
<td>0.404*</td>
<td>-0.114</td>
</tr>
<tr>
<td>Exercise Intervention</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluency</td>
<td>0.002</td>
<td>0.232</td>
<td>0.340</td>
<td>0.016</td>
</tr>
<tr>
<td>Acceptability</td>
<td>0.044</td>
<td>0.199</td>
<td>0.376</td>
<td>0.124</td>
</tr>
<tr>
<td>Flexibility</td>
<td>0.002</td>
<td>0.223</td>
<td>0.343</td>
<td>0.068</td>
</tr>
<tr>
<td>Originality</td>
<td>-0.018</td>
<td>0.122</td>
<td>0.304</td>
<td>0.215</td>
</tr>
<tr>
<td>Elaboration</td>
<td>0.153</td>
<td>0.003</td>
<td>0.201</td>
<td>0.277</td>
</tr>
<tr>
<td>Total Score</td>
<td>0.005</td>
<td>0.125</td>
<td>0.248</td>
<td>0.135</td>
</tr>
</tbody>
</table>

* p≤0.05  \( \triangledown \) p≤0.10

*Figure 3.* Scatterplot of Significant Correlation. The significant Pearson Correlation Coefficient between Total GAU Score from the rest condition and VO₂ Fat Free Mass was further explored via scatterplot.
Discussion

This study intended to expand upon the limited literature investigating the influence acute aerobic exercise has on creative ability; however, the results revealed that a twenty-minute bout of moderate-intensity exercise did not significantly affect creativity performance as measured by the GAU task in 8-10-year-old children. Additionally, weight category did not have an influence on GAU creativity scores following exercise. There was however a positive correlation between fat-free VO₂ and total GAU scores across all participants following rest, which may indicate a relationship between chronic fitness level and overall creativity at rest. The interest in these two outcomes may be better explored with a larger, more equally distributed sample size. This may decrease the within group variability, especially when comparing the larger sample size of the normal weight group to the smaller sample size of the overweight/obese group.

These non-significant findings are in contrast with previous findings in the field, which suggest that physical activity influences creativity (17, 18, 19). There are variations between all of the studies’ protocols, which may account for some of these differential results. The studies differed in creativity measures: the GAU compared to the Torrance Assessment or collage making. Additionally, the age range for children in each of these studies differed. However, all three studies incorporate some form of physical activity, whether that be acute aerobic, chronic aerobic, or simple playtime at school activity. The slight differences in these studies is promising to the degree that there is a link between physical activity and creativity; however, the variability also suggests that the exact nature of the relationship has yet to be determined, making opposing results such as ours more likely to emerge until that exact nature has been pinpointed.

Characteristically, the population analyzed is a novel group in the realm of studying acute, aerobic exercise and creativity and may explain some of the differences in the observed results. As Oppezzo and Schwartz recruited a college-aged young adult population and saw a beneficial effect of exercise on creativity, it is possible that the influence acute exercise on creativity may emerge at a later age in development than the 8-10-year-old population of the current study.
Limitations

There are several potential components of the study that may explain why the results defy previous findings. Firstly, it is important to consider that the grading process and the generation of responses for the GAU are both highly subjective. We attempted to reproduce the findings of Oppezzo and Schwartz in a differing age population; however, there were differences in the study design. Rather than conducting a pre- and post-test of creativity on both intervention days, creativity was only assessed after each intervention, thus we do not know if performance is different from before each intervention since we can only make comparisons after each intervention. Additionally, our study had participants write responses, while responses were verbalized in Oppezzo and Schwartz (2014). While written responses take more time and increase the possibility for distraction, verbal responses may elicit more innate responses as children are less enabled to filter their thoughts. We decided to have children write their responses as it is a more confidential process, which may spark a sense of individual creativity as they are less likely to feel judged by the experimenter. A final, noticeable limitation in the study was total number of participants. While the total participant count was twenty-five, there was not an equal distribution between the two weight categories. By only having six overweight/obese participants, the within group variability, especially in the exercise intervention, was high.

Future Directions

Ultimately, the findings of this study do not have largely subversive implications on the area of study with respect to creativity and exercise, but rather warrant a greater exploration in both the field and the age population at hand. Possible future directions include continuing the current study with specific interest in increasing the subject pool, in order to decrease within group variability. Additionally, including a stricter set of guidelines for appropriate answers may decrease variability. Creative thoughts are subjective, highly individualized experiences, and therefore specific guidelines may account for some of the variability within both the nature of creative thought itself. Another direction to explore would be to slightly alter the study, by better replicating the methods and procedures used by Oppezzo and Schwartz (2014), such as creating a pre- and post- design study, to possibly give insight to the effects of creativity after exercise in children. Finally, an important consideration in future studies would be to repeat the protocol on a slightly older population, potentially one post-puberty, to see if puberty and thus maturation of
creative thought is a mediating factor that distinguishes the results of 8-10-year-old children from college-aged students. In exploring these directions, our study may better coincide with previous findings, supporting the claim that exercise does in fact influence creative thought.

The main concern from the results of this study stem from the concept of creativity itself; it is contentious across the field as a difficult construct to measure. Until further research is conducted, our study may point to the concerns addressed by Sternberg and Grigorenko (2001) and Michael and Wright (1989) about the subjective psychometric nature of the GAU (30, 31). However, it is essential to note that the GAU continues to be the gold standard in terms of creativity testing, and the outcomes of studies incorporating the assessment remain well accepted among the scientific community. The GAU has been shown to be both reliable and valid in child studies. (32, 33). Future studies could examine these studies’ parameters to see how potentially physical activity could be incorporated into the paradigm and if it influences these young age populations.

Conclusion

Creativity is a novel field within cognitive science. Therefore, regardless of the method of creativity testing, the concept of creativity will continue to be solidified as researchers continue to delve into the relationships between creativity, and other domains such as exercise. Additionally, studies such as Steinberg et al. (1997) have eliminated potential mediating factors, such as mood elevation, between these two areas of research, strengthening the argument that there is a direct relationship between exercise and creativity to be explored (34). Finally, with sedentary lifestyles and obesity rapidly on the rise, and the substantial impact creativity may have on academic success, career success, and daily behaviors, the relationship between creativity and physical activity remains extremely relevant and unanswered. In addition, the precise age at which creativity is influenced by exercise, is of great importance and remains unanswered. If exercise has not only the ability to diminish the obesity epidemic and its lifelong consequences, but to also improve creative thinking in grade aged children, it may alter how we educate children, and the value we place on physical activity in the education system.
Conflicts of Interest

The author has no conflicts of interest to report.

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References


20. What is creativity? (n.d.). California State University Northridge. Retrieved from csun.edu/~vcpsy00h/creativity/define.htm


