

Acute Impact of Mindfulness Meditation on Cognitive Performance

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The beneficial effects of mindfulness meditation on higher-order cognitive performance as well as physiological parameters, such as decreased cortisol levels, blood pressure, pulse rate, and reaction time, have been studied extensively. However, most of these studies have been conducted over a relatively long term, comparing subjects who meditate on a regular basis with those who have never meditated. In this study, the acute effects of mindfulness meditation are investigated by examining the differences between tactile reaction time and temporal-order judgement (TOJ) obtained before and after a 10-minute meditation session in several case studies. Additionally, the participants reported their mood and stress levels in a survey before and after the meditation session. The results demonstrate that mindfulness meditation improves performance on the tactile reaction time and TOJ tasks, and it also promotes a peaceful state of mind.

Citation

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Introduction

Originating from ancient Eastern traditions, the practice of meditation remains a prominent topic of study within the fields of clinical psychology and behavioral neuroscience. Mindfulness is a specific form of meditation that is defined as “a kind of nonlaborative, non-judgmental, present-centered awareness in which each thought, feeling, or sensation that arises in the attentional field is acknowledged” [1]. In other words, mindfulness meditation is a mental practice based on focusing on the sensation of the breath while maintaining a relaxed state of mind.

Many studies have examined the effects of meditation and breathing exercises on cognitive performance. Mindfulness meditation has been shown to enhance attentional and visual spatial processes [2,3]. Meditation for 10-12 hours a day over the course of three months improved the ability to sustain attention during dichotic auditory stimuli through faster reaction times and reduced attentional blinks compared to controls [4,5]. Other studies observed that long term intensive meditation practice led to decreased cortisol levels, lower blood pressure, pulse rate, and reaction times [6]. In a study using functional MRI, the meditation training increased cerebral activation in regions correlated with improvements in sustained attention and error monitoring [7]. These findings provide growing evidence that mindfulness meditation promotes higher-order cognitive processing.

The cognitive benefits associated with mindfulness have been limited to studies examining long-term meditators [8]. The present study explored the acute impact of breath counting, a form of mindfulness meditation, on college-aged students with a specific focus on cognition. We

hypothesized that breath counting will result in faster tactile reaction time and improve temporal order judgement (TOJ). Based on previous studies, we expected that acute mindfulness meditation would have the greatest effect on these tasks. We also expected that a brief mindfulness meditation procedure would promote positive mood, as measured through self reporting.

Methods

Participants

Several case studies (n=6) were conducted that tracked the perceived discomfort, stress levels, reaction time, and TOJ scores of individuals before and after a mindfulness session in order to understand the acute effects of mindful meditation. Each individual read a provided experimental purpose and instructions sheet and provided feedback to the study and the cases were de-identified to maintain confidentiality.

Questionnaires

In order to measure changes in stress levels and perception of discomfort, a pre-treatment and post-treatment survey were provided before and after the 10-minute meditation or control test session. The pre-test questionnaire asked for one's test ID, sex, age, extent of discomfort at the time, perception of the impact of stress on daily activities, and current stress levels. The post-test questionnaire inquired about the extent of discomfort and levels of stress post-test, whether one felt relaxed during the video, hours of sleep from the night before, and additional notes such as caffeine intake that may have affected relaxation or alertness before the study. Factors such as sleep and caffeine intake were surveyed in order to screen participants for a lack of focus or errors that may have affected battery results.

Procedure

After filling out the pre-treatment survey, participants were asked to use the Brain Gauge App to run a battery of cognitive tests. The first test was a simple reaction time test. In this test, participants touched their right index and middle finger to the left and right tactile pads on the Brain Gauge respectively. The right tactile pad on the Brain Gauge would vibrate at random intervals, at which point the participants pressed down on the Brain Gauge with their index finger as quickly as they could. Participants had three practice trials to familiarize themselves with the test before 20 real trials were conducted.

The second test in the cognitive battery was a temporal-order-of-judgment (TOJ) test. For this test, the participants placed their right index and middle finger on the left and right tactile pads on the Brain Gauge respectively. The left and right pads vibrated in a random order and then the participants depressed the pad they believed vibrated first. The participants were given three practice trials for which they received feedback on whether they were correct. Then, 20 real trials were conducted with the interval between vibrations decreasing in later trials.

After completing the pre-treatment questionnaire and Brain Gauge battery, participants underwent a 10-minute instructed activity. Participants watched a guided meditation follow-along video that did not have any words and displayed a visual control indicating cues for inhalation and exhalation. After meditating with the video, participants were asked to run the same battery of cognitive tests as before, this time noting their anxiety level on a 1-5 scale before the test, with 1 being anxious and 5 being relaxed. After running the post-meditation battery, participants filled out the post-treatment survey described in the Questionnaire section.

Results

Six participants completed case studies. Based on the data gathered from these participants, a decrease in average reaction time was seen, along with a smaller variability in the reaction time (Figure 2). TOJ values were higher in participants after meditation (Figure 3). A t-test was performed to determine if these differences were statistically significant (Table 1). Additionally, individual subject scores were compared by looking at the reaction time absolute difference (Figure 4), and the percent change (Figures 5–7). Most of the subjects showed a decrease in TOJ, reaction time, and reaction time variability, with the exception of subject 1, who showed an increase in TOJ, subject 2, who showed an increase in reaction time, and subject 3, who showed an increase in TOJ and reaction time variability (Figure 4). When looking at their responses to the questionnaires, subject 2 indicated that they were not relaxed in addition to ranking the extent to which stress affects their performance to be an 8 out of 10, which could explain their increase in reaction time. Subject 3 ranked the effect of stress to be a 6 out of 10, showed no difference in stress levels after meditation, and were in extreme pain both before and after meditation, which could explain the increase in TOJ and reaction time variability. In analyzing the significance of the reaction times for the subjects, we found that the subjects that had a decreased reaction time after meditation were statistically significant (Table 2). Subjects 2 and 4, who had a slight increase in their reaction times, weren't statistically significant.

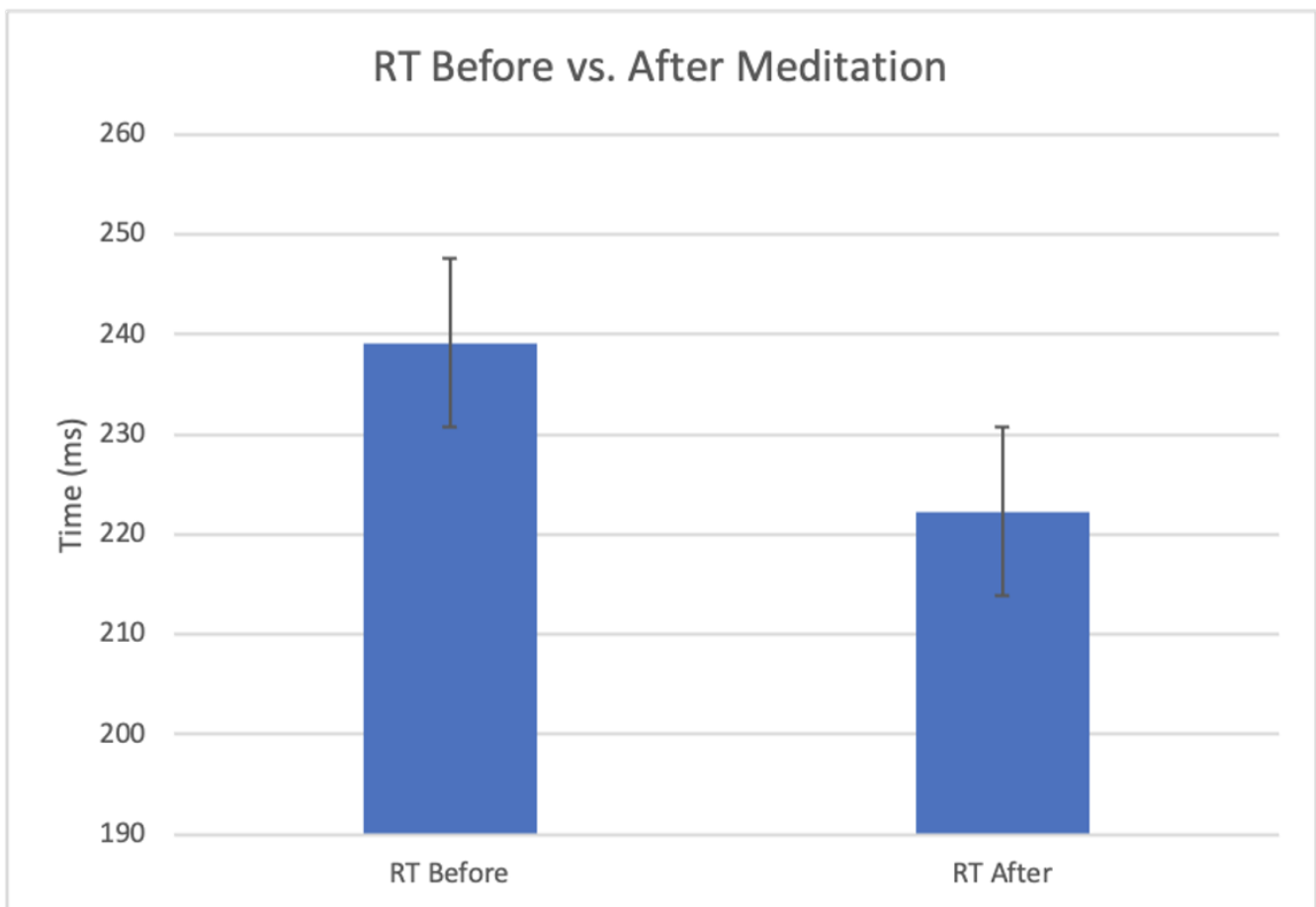


Figure 1. Reaction time before and after meditation for all 6 participants. The error bars were calculated using the standard error.

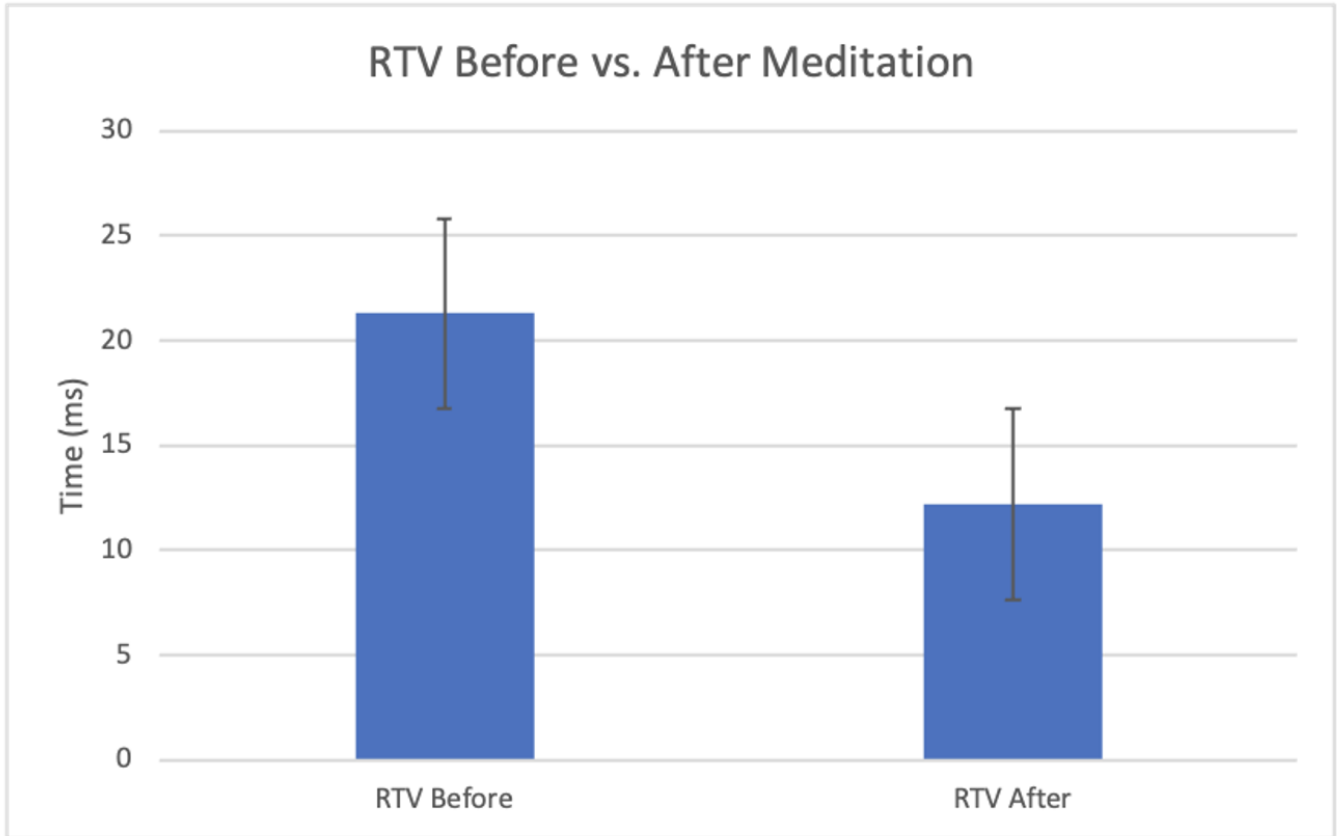


Figure 2. Reaction time variability before and after meditation for all 6 participants. The error bars were calculated using the standard error.

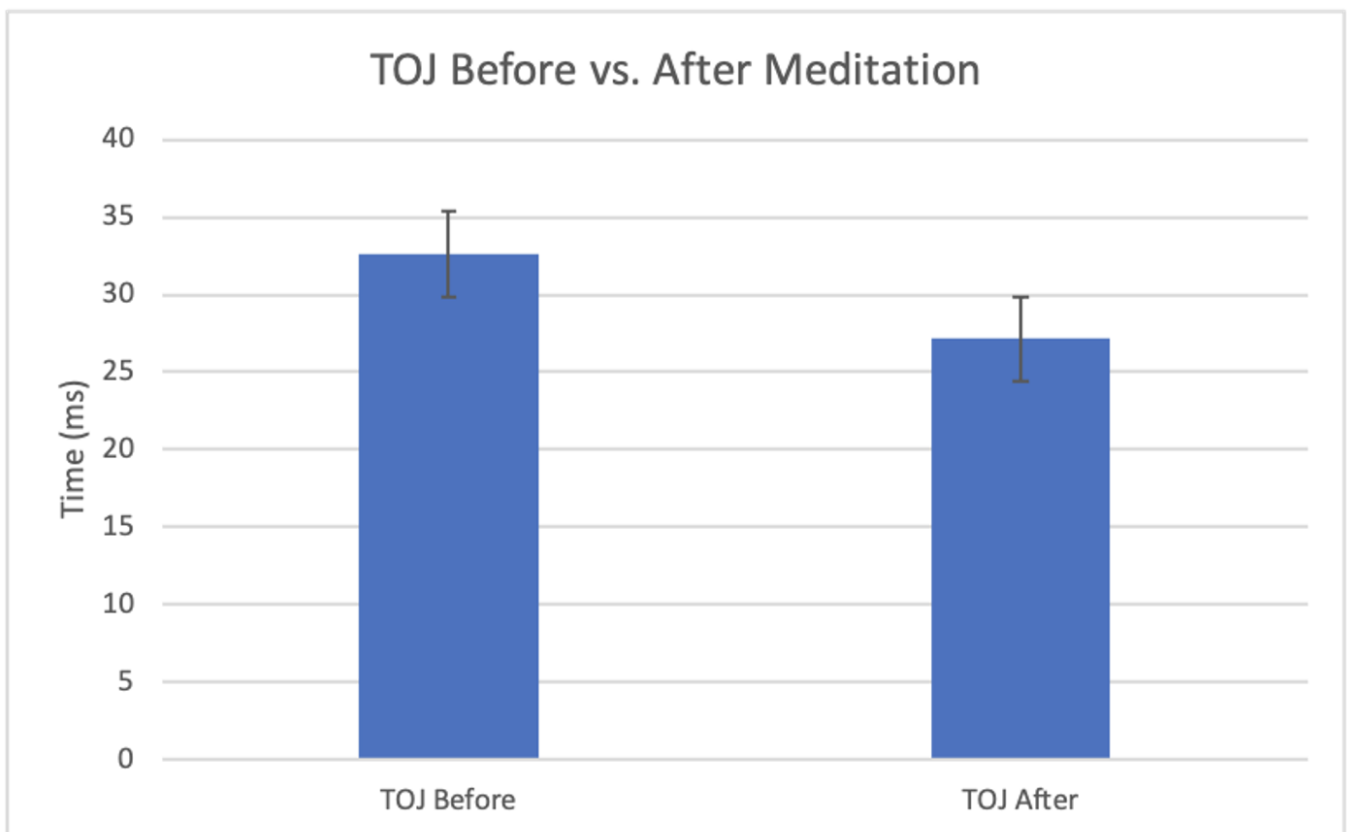


Figure 3. TOJ before and after meditation for all 6 participants. The error bars were calculated using the standard error.

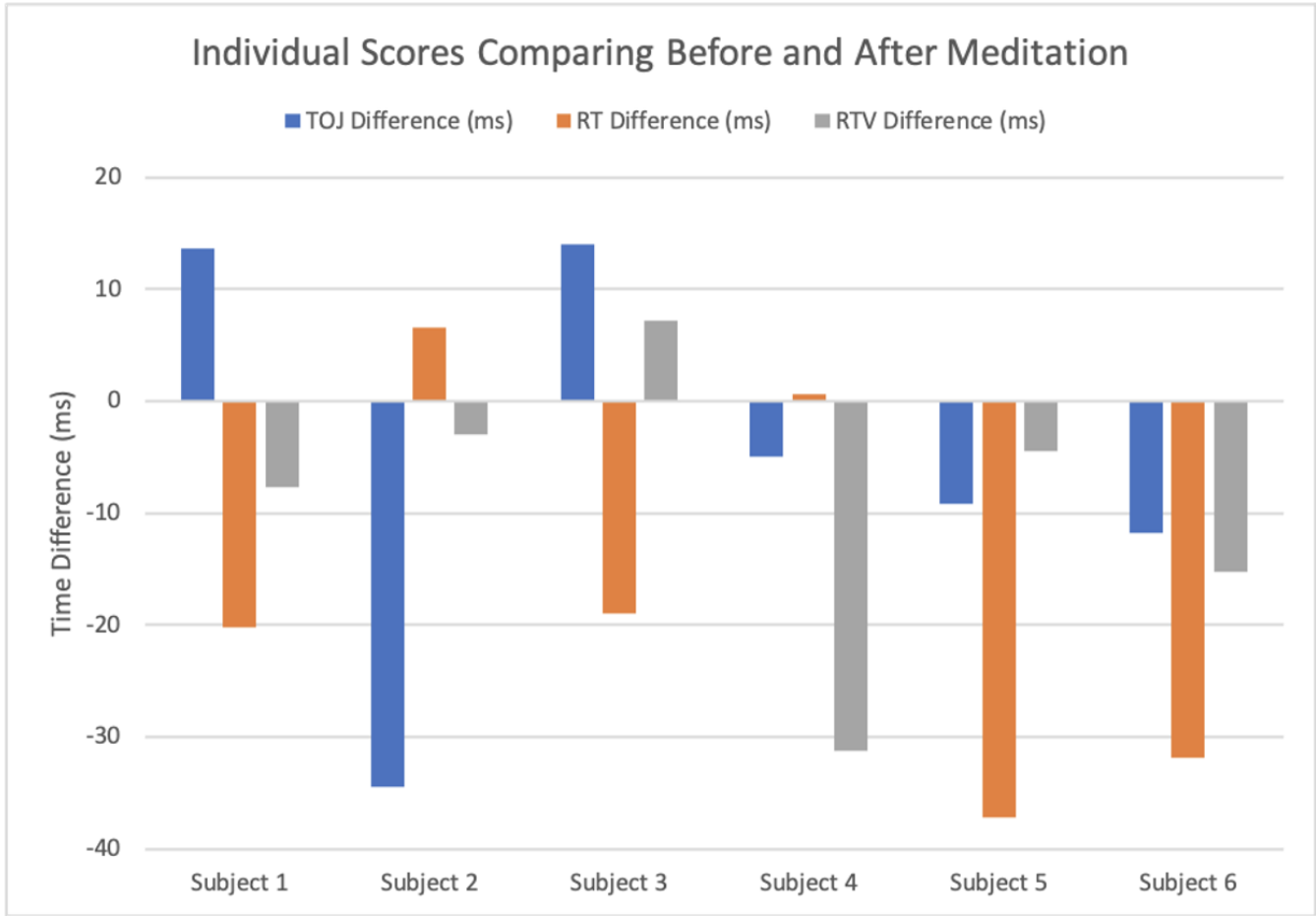


Figure 4. Individual subject scores comparing before and after meditation. These scores were calculated by subtracting their score before meditation from their score after meditation. A positive value indicates that the score increased after meditation, and a negative value indicates that the score decreased after meditation. Blue bar represents TOJ, orange bar represents reaction time, and gray bar represents reaction time variability.

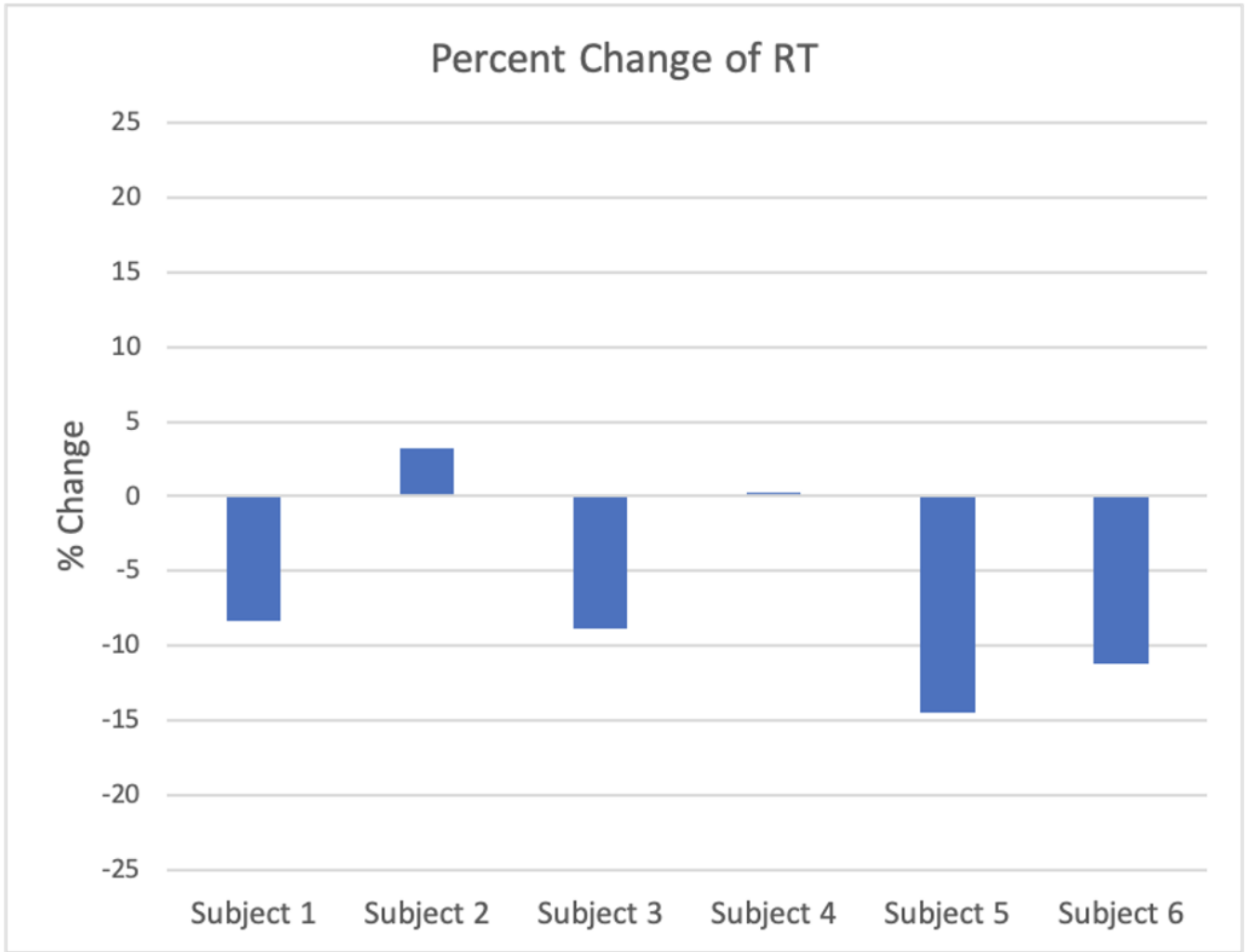


Figure 5. *Percent Change of RT.* These values were calculated by subtracting the reaction time before meditation from the reaction time after meditation, then dividing this value by the reaction time before meditation and multiplying by 100.

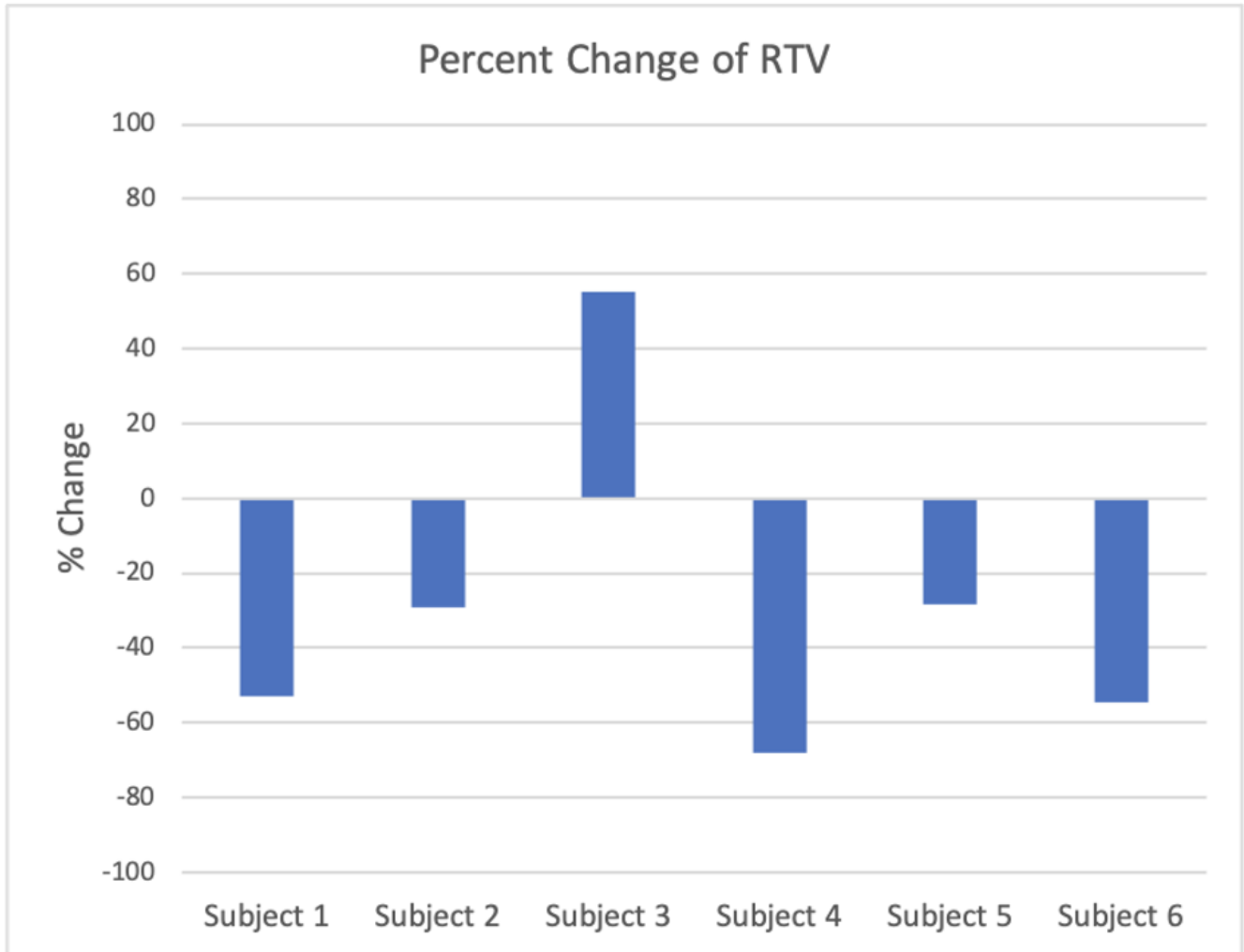


Figure 6. Percent Change of RTV. These values were calculated by subtracting the reaction time variability before meditation from the reaction time variability after meditation, then dividing this value by the reaction time variability before meditation and multiplying by 100.

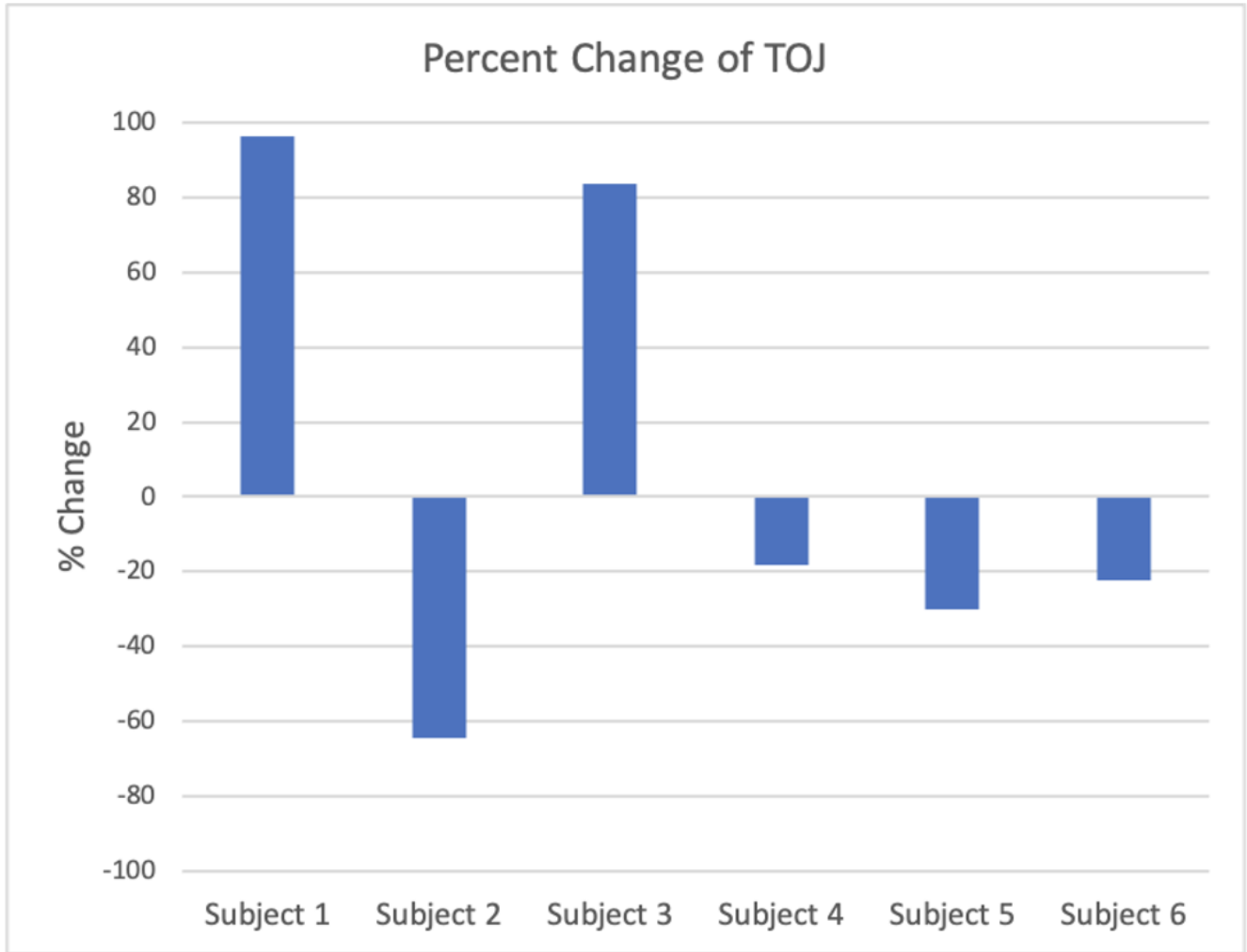


Figure 7. Percent Change of TOJ. These values were calculated by subtracting the TOJ before meditation from the TOJ after meditation, then dividing this value by the TOJ before meditation and multiplying by 100.

Category	T-Test Value
RT	0.2467 (ns)
RTV	0.1529 (ns)
TOJ	0.2896 (ns)

Table 1. T-Test values when comparing values before and after meditation, where ns denotes no significance.

Subject	RT
Subject 1	0.0009
Subject 2	0.1156 (ns)
Subject 3	0.0229
Subject 4	0.9690 (ns)
Subject 5	<0.0001

Table 2. T-Test values when comparing individual reaction times before and after meditation, where ns denotes no significance.

Discussion

The results of the mindfulness meditation study show a general trend in decreasing reaction time, decreasing reaction time variability, and decreasing TOJ – all indicators of improvements in

cognitive performance. All subjects with a decreasing reaction time were statistically significant whereas the subjects that showed an increase in reaction time were not. This indicates that even short-term meditation can have significant impacts on an individual's performance. The reduction in reaction time and its variability may be due to a variety of factors that includes better attention and/or reduced anxiety and stress. Likewise, TOJ could similarly be decreased due to the same variety of factors. Some reduction in reaction time and decrease in TOJ score may be attributed to repetition of the test (i.e., potentially a learning effect).

One limitation of this study is the low number of participants, and the statistical analysis could significantly benefit from having more data points to draw conclusions from. Another limitation of the study is that it represents a homogenous subject population. All of the case study participants were university aged students and none had any major cognitive or physical deficits. While a more robust but similar study may show a positive effect of short-term meditation on cognitive performance in a young and healthy population, the effects of meditation on cognitive performance may be more interesting to study in an older or cognitively deficient population.

Noting how mindfulness meditation correlated with a decrease in reaction time and decrease in TOJ, the authors think that it would be beneficial to conduct more studies to improve the accuracy and depth of results, as well as quantify physiological indicators of cognition and stress. Moving forward, we would like to control confounding factors such as caffeine intake and lack of sleep from the night before by including guidelines of conduct required before taking the provided test. This study could be modified into a longitudinal study, where we would see the effects of mindfulness meditation of a sample over an extended period of time. With a longitudinal study, physiological signals such as heart rate, blood pressure, and brain activity can be measured. A cognitive measure of memory can be additionally observed with reaction time and TOJ. Another method we could explore in our future studies is to observe differences in the longitudinal effect of an experiment-controlled consistent mindfulness meditation between groups that are novices at meditation and groups that are very experienced. Another approach could be taken and have different groups of subjects perform mindfulness meditation for varying lengths of time in order to observe at what time length meditation first makes a significant difference in the subjects' performances.

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