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The Necker Cube – An Alternative Measure of Direct Attention

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Abstract

The Attention Restoration Theory (ART) states that there are two kinds of attention: involuntary and voluntary[3]. Involuntary attention is a form of attention that requires no effort, happens naturally, and is resistant to fatigue, while voluntary, or direct, attention is a form of attention that requires effort and focus, is susceptible to fatigue, and can be used to block out distractions[3]. According to ART, during times one isn't using direct attention, whether the individual is paying involuntary attention or not, the direct attention capacity of that individual can recoup to its original level with enough time[3]. We can measure direct attention by using a reverse digit span test[1]. However, it is hypothesized that another method using the Necker Cube could also measure direct attention. This is significant because the Necker Cube method of measuring direct attention would be more portable, time efficient, and easier to administer than the reverse digit span method. The Necker Cube is a 3-D, line drawing of a cube that naturally varies or reverses between two orientations. The frequency of fluctuation is predicted to be a measure of attention. In order to show this, the volunteers in the experimental study were asked to look at the Necker Cube for a minute and mark every time they see it reverse. The volunteers were then asked to do some simple math without taking notes for varying time increments (1 minute, 2 minutes, or 3 minutes) and to write down the answers. Finally, the volunteers were asked to look at the Necker Cube for a minute and mark how many times it reversed. By having the volunteers do simple math, the individuals' direct attention is fatigued; thus, the frequency of reversal should increase. There was a significant effect of performing mental math and fluctuation increased significantly ($F(1,142)=4.61$, $p=0.03$). The change did not vary for the varying time increments of simple math. This suggests that the Necker Cube can be used as a measure of direct attention.

Keywords: Necker Cube, Attention, Reversals

1. Introduction:

Attention Restoration Theory (ART) states that there are two kinds of attention: involuntary and voluntary. Involuntary attention is a form of attention that requires no effort, happens naturally, and is resistant to fatigue, while voluntary, or direct, attention is a form of attention that requires effort and focus, is susceptible to fatigue, and can be used to block out distractions[3]. The difference between these two kinds of attention is not only conceptual, they've been measured in human cognitive processes and related to activity in the brain. Voluntary attention, also known as direct attention, is reliant on the "frontal and parietal cognitive control structures" while involuntary attention is less reliant on these specific areas[2].

The more influential of these two types of attention is direct attention. Berman and Kaplan refer to it as a "limited resource[2]." Direct attention is to the human mind like gasoline in a vehicle. The human brain harnesses this resource to power executive functioning and self-regulation[2] much like gas is for cars. Executive functioning is a high level cognitive function dealing with inhibitory control and attention switching. Self-regulation is a function that enables the resistance of temptations and to behave appropriately. These two functions are linked [shown by studies Baumeister et al. (1998) and Schmeichel et al. (2003)] and draw off the same resource: direct attention. For

example, the Posner, Rothbart, Sheese, and Tang (2007) suggest through neuroimaging data that "control of cognitions and of emotions is heavily reliant on the anterior cingulated cortex[2]. As a car fails to function when out of gas, the human brain fails to function without the resource of direct attention, and abilities like giving undivided attention or managing emotions begin to fail[2]. In fact, this limited system is an adaptive advantage. As stated in Berman and Kaplan's paper titled *Directed Attention as a Common Resource for Executive Functioning and Self-Regulation*:

> Consider the implications of possessing an unlimited quantity of this resource. This would make it possible, for example, to focus on certain portions of the environment for as long as one would like. This, in turn, gives on the capacity to ignore everything else for an indefinitely long time. Just as wild ungulates cheerfully consuming a patch of delicious foliage look up intermittently (reducing the likelihood that anything could sneak up on them), being too preoccupied to scan for potential hazards would also have been dangerous for our ancesters (pg. 45)[2]

Thankfully, direct attention is not a "one-time-use" item.

According to ART, during times an individual isn't using direct attention, when involuntary attention is engaged, that individual's voluntary attention capacity recovers. With enough time, voluntary attention can recover to its original level[3].

Currently, one common measure of direct attention is the reverse digit span test[1]. Other methods of direct attention measurement have been used including extensive proof-reading[3] and the Attention Network Task[1]. However, these forms of measurement are very complex and time consuming. So the question is: does there exist a method of measuring direct attention that is easier to use?

This study looks into another method of measuring direct attention that utilizes the Necker Cube. This is significant because the Necker Cube method of measuring direct attention would be more portable, time efficient, and easier to administer than the reverse digit span method. The Necker Cube is a 3-D, line drawing of a cube that naturally reverses between two orientations (Figure 1).

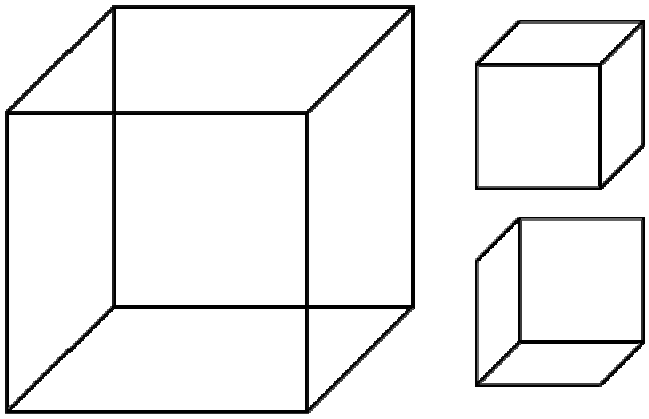

Figure 1. 3-D drawing of a Necker Cube and its two orientations

The frequency of reversal between its two orientations is predicted to be a measure of attention.

2. Methodology:

2.1 Participants

The study included 148 undergraduate students participating in partial fulfillment of a course requirement or as volunteers. These volunteers were assigned to one of three groups. There were 50 volunteers in the group that performed 60 S of mental math, 39 volunteers in the group that performed 120 S of mental math, and 59 volunteers in the group that performed 180 S of mental math.

2.2 Materials

The volunteers in the Necker Cube groups were presented with an image of a Necker Cube. They also saw a series of single digit numbers and mathematical operators, +, - or =. All these images were projected onto a screen at the front of the classroom. Volunteers recorded their response on data sheets formatted for the study.

2.3 Procedure

The volunteers were tested in a standard classroom with multiple experiments present. The volunteers in the experimental study were asked to look at the Necker Cube for a minute and mark every time they see it reverse. The volunteers were then asked to do some simple math without taking notes for varying time increments (1 minute, 2 minutes, or 3 minutes) and to write down the answers. Finally, the volunteers were asked to look at the Necker Cube for a minute and mark how many times it reverses. By having the volunteers do simple math, the individuals' direct attention was fatigued; thus, the frequency of reversal should have increased.

3. Data

The primary dependent measure in this study was the number of times the volunteers reported that the Necker cube's orientation reversed. This measure will be called reversals. Table 1 and Figure 2 show the average pre and post mental math reversal counts for all three groups and standard errors for these means. There was no significant difference between the three groups in the pre or post measure of reversals. Further, there was no significant difference between the pre mental math and post mental math reversals for any of the three groups. Thus, the three groups were combined for a final analysis of the overall effect of mental math.

A simple analysis of variance found that the number of reversals increased significantly in the post measure, $F(1,294)=6.58$, $p=0.01$. The pre and post mental math means were 9.03 and 11.41, with standard errors of 0.61 and 0.7, respectively.

Table 1. mean reported reversals before and after 60, 120 and 180 seconds of mental math

	60"	120"	180"
	M (SEM)	M (SEM)	M (SEM)
Pre mental math	9.62 (1.37)	7.08 (0.93)	10.12 (0.93)
Post mental math	12.08 (1.40)	9.67 (1.12)	12.34 (1.07)

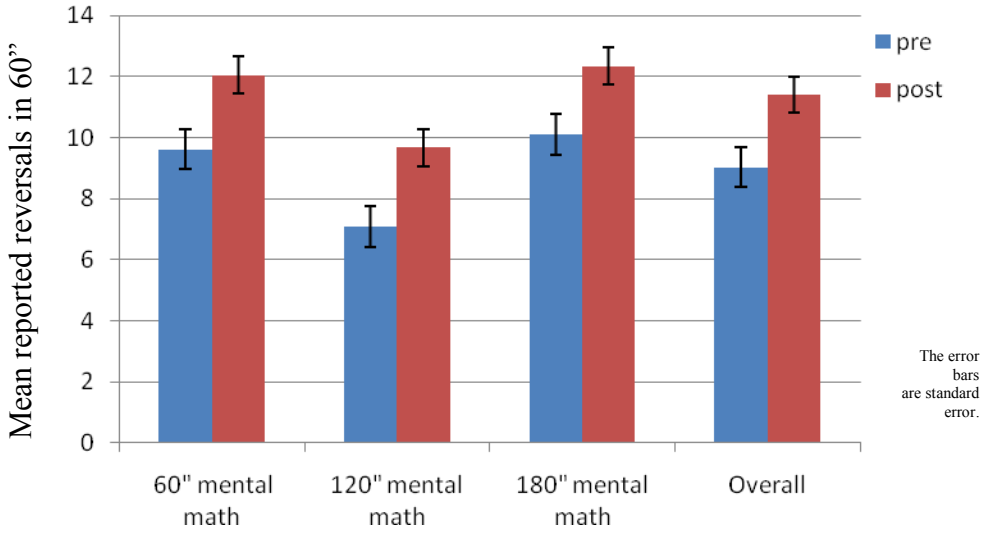

Figure 2. Mean reported reversals before and after 60, 120 and 180 seconds of mental math

4. Conclusion

These date suggest that the Necker Cube can be used as a measure of direct attention. This is useful because the traditional measurements of direct attention are time consuming and cumbersome. The Necker Cube is a much shorter, simpler, and highly mobile test to measure attention. This makes it useful and valuable for the current research in ART. Instead of having a participant spend time in a natural setting before returning to complete the reverse digit span or another method of measuring direct attention, the Necker Cube will allow the scientist to measure the participant's direct attention on site while the individual remains in the natural setting. This removes any inconsistencies in the data because of the time gap. This would have been useful with Experiment 1 in Berman, Jonides and Kaplan (2008), which was designed to compare the results of interactions with natural versus urbanized settings[1]. In this study, participants walked in a park, then had to return to the lab to do the backwards digit-span task. The time gap, as previously stated, can corrupt the data or diminish the difference between before and after data.

Other studies have been conducted on direct attention using the digit span test as a dependent measure after manipulating things such as sleep, meditation, and glucose levels[1]. In all of these cases the efficiency and portability of the Necker Cube measure would have been an advantage.

In the current study, it is important to acknowledge that we may run into problems with mathematical ability and variations in ability may have been confounded with the effect of fatigue. Some work has used proof-reading as a measure of direct attention fatigue[4], but some volunteers may have limitations with that as well. The newest fatigue task asks participants to scan a document for certain letters and marking them, which requires no skill but it's a fatiguing task.

Overall, these data are important because direct attention plays a critical role in a purposeful and successful life. Knowing how to keep direct attention at its maximum performance can help one live a healthier life by making better mental health decisions. When one knows more about the effects the environment can have on physical and mental well-being, he or she can make healthier decisions.

5. Acknowledgements

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6. References

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