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Title: The Role of Cognitive Control in Paranormal Beliefs: A Study Based on Performance in Go/No-Go Task

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Abstract

Cognitive control plays a role in human behavior and mental processes, and paranormal beliefs seem to be affected. This study aimed to investigate the role of cognitive control in Paranormal Beliefs using the Go/No-Go Task. Ninety-two people were selected based on low, middle, and high scores in the Revised Paranormal Belief Scale(R-PBS) (Tobacyk, 2004) and were classified into three groups. This produced 30 Severe Paranormal Believers (13 females, mean age 25.3 years), 31 Mild Paranormal Believers (14 females, mean age 26.4 years), and 31 Skeptics (16 females, mean age 25.8 years). All participants were tested on the Go/No Go Task. A multivariate analysis of variance was conducted with the group (Severe Paranormal Believers, Mild Paranormal Believers, and Skeptics) as the independent variable and the Go/No Go subscales scores as dependent variables. The findings show that there is a significant difference between the mean scores in Errors(Go) ($F_{2,89}=7.20$, $p=0.01$) , Errors(No- Go) ($F_{2,89}=11.81$, $p=0.01$) and Reaction Time ($F_{2,89}=21.46$, $p=0.01$) between the groups. The Severe Paranormal Believers and Mild Paranormal Believers had lower accuracy and slower RT than the Skeptics group. Therefore, Severe Paranormal Believers and Mild Paranormal Believers had a weakness in all Go/No-Go subscale scores. This finding suggests that paranormal beliefs may related to poor cognitive control.

Keywords: Cognitive Control, Paranormal Beliefs, Go/No-Go Task.

1. Introduction

Paranormal beliefs are beliefs, entities, practices, and processes that contradict the basic limiting principles of science (Tobacyk, 2004). Paranormal beliefs are generally determined by asking individuals how often they think in paranormal experience. Examples include ghosts, witches, amulets, omens, rituals, astrology, psychokinesis, and extrasensory perception (i.e., telepathy, precognition, and clairvoyance)(Lindeman & Svedholm, 2012). It seems individual differences in cognitive-perceptual bias make people susceptible to paranormal beliefs (Irwin, 2009; Narmashiri, Sohrabi, & Hatami, 2017, 2018). For example, it associates paranormal beliefs with a strong tendency to mistakes in decision-making (Riekk, Lindeman, Aleneff, Halme, & Nuortimo, 2013; Van Elk, 2013), the perceptual bias in obscure categories (Lindeman & Aarnio, 2007; Lindeman, Svedholm-Häkkinen, & Lipsanen, 2015), and dependence on Intuitive thinking compared to analytic thinking (Pennycook, Cheyne, Seli, Koehler, & Fugelsang, 2012; Prike, Arnold, & Williamson, 2017). studies show that decision-making and cognitive biases in people with paranormal beliefs result from cognitive impairment (Irwin, 2009). It seems paranormal believers do not have the necessary cognitive skills and abilities (van Elk, 2017).

Belief in paranormal phenomena is associated with various cognitive failures, including errors in probability reasoning (P Rogers, 2015; Paul Rogers, Fisk, & Lowrie, 2018). Dagnall et al (2017) believe that this issue has a strong tendency for paranormal believers to recognize and perceive accidental. On the other hand, some studies have reported the prevalence of intuitive thinking in paranormal beliefs (Prike et al., 2017), and analytical-rational thinking reduces somewhat paranormal beliefs (Gervais & Norenzayan, 2012; Pennycook et al., 2012). However, the difference between analytical-rational thinking and intuitive thinking in reasoning and interpretation of events is controversial (De Neys & Van Gelder, 2009). The fundamental questions discussed are whether analytical-rational and intuitive processes compete for dominance over another, or there is a specific mechanism for regulating these reasoning processes. A mechanism that may involve suppressing

intuitive thinking in the tendency to paranormal beliefs is cognitive control (Riekk, 2014).

Cognitive control leads to controlling inappropriate or unwanted responses in individuals and is identified as one of the essential aspects of executive functions (Friedman & Miyake, 2004). Studies have shown that there is a relationship between paranormal beliefs and poor cognitive control (Lindeman & Svedholm, 2012; Riekk, 2014; Wain & Spinella, 2007). Whereas strong cognitive control reduces it (Aron, Robbins, & Poldrack, 2004; Pennycook et al., 2012). Besides, it seems relates weakness in cognitive control to intuitive thinking (Moutier & Houdé, 2003), Schizophrenia (Nigg, 2000), religious and obsessive-compulsive disorder (Dewhurst & Beard, 2003), which are closely related to paranormal beliefs and experiences (Brugger & Mohr, 2008; Lindeman & Aarnio, 2007; Wiseman & Watt, 2006). It is believed that the reduction of cognitive control increases paranormal beliefs (B. Hood, 2009).

Thus, cognitive control deficits across a range of cognitive domains overlapping with supernatural beliefs such as schizophrenia (Lesh, Niendam, Minzenberg, & Carter, 2011) and are associated with decreased activity in the DLPFC (Lesh et al., 2013) and the rIFG regions (Lindeman, Svedholm, Riekk, Raij, & Hari, 2012). Since the DLPFC and rIFG regions are related to the neural network of cognitive control, this neural network function is defective in paranormal believers. Studies have shown that the DLPFC and the rIFG regions are related to the inhibition mechanism (Braver, Paxton, Locke, & Barch, 2009; Chiew & Braver, 2013). In this regard, in a study, Lesh et al. (2013) showed that the DLPFC region of individuals with primary schizophrenia did not have significant activity during cognitive control tasks than the control group, while the DLPFC region activity of the control group increased. Also, Fassbender, Scangos, Lesh, and Carter (2014) showed that people with schizophrenia had lower cognitive control scores than the control group. Besides, Lindeman et al. (2012) showed that the rIFG region has an intense skepticism compared to paranormal believers. Therefore, according to previous studies and the relationship between brain regions with

cognitive control in paranormal beliefs, we want to investigate whether poor cognitive control is associated with a tendency to a variety of supernatural beliefs and increase those beliefs. Its result may play an important impact on paranormal beliefs.

2. Methods

2.1. Participants

Participants were selected from the student population who had previously not participated in the study of paranormal beliefs. All participants were full-time university students and were students in psychology. The age of participants ranged from 19 to 35 years ($M = 28.0$, $SD = 11.9$) and formal education ranged from 9 to 20 years ($M = 14.8$, $SD = 1.6$). Ninety-two people were selected based on mean scores low, middle, and high on the Revised Paranormal Belief Scale(R-PBS) (R-PBS) (Tobacyk, 2004). They were classified into three groups (Severe Paranormal Believers, Mild Paranormal Believers, and Skeptics). In other words, participants who scored high mean on the R-PBS were considered as the severe paranormal believer's group (first group). Also, participants who scored the middle mean on the R-PBS were considered the Mild Paranormal Believers group (second group). Finally, participants who scored low mean on the R-PBS were considered the Skeptics group (third group). This produced 30 Severe Paranormal Believers (13 females, mean age 25.3 years), 31 Mild Paranormal Believers (14 females, mean age 26.4 years), and 31 Skeptics (16 females, mean age 25.8 years).

2.2. Measurement

All participants were tested on the Go/No Go pictorial Task(Fillmore, Rush, & Hays, 2006). In this test, two-colored rectangles (green and blue) were presented horizontally and vertically as a stimulus to the participants. They were then asked to respond only to the green rectangle and ignore the blue rectangle and not consider whether the rectangle was horizontal or vertical when answering. In other words, we requested the participants to press the space bar on the laptop keyboard when presenting the green rectangle, both horizontally and vertically rectangles.

Otherwise, do not press the key. Therefore, in this test, the person in a position (Go-green rectangle) by providing an actuator should provide as soon as possible a responsive response to the stimulus. Another stimulus is presented after providing the first stimulus in the other position (No Go- blue rectangle). The person with the advent of the second stimulus should refuse to answer. Two types of positions (Go-green rectangle and No Go- blue rectangle) are randomly assigned to one pictorial task. An individual's ability to control his response in the second position is an indicator of control. The following sub-scales were used for analysis: Error(Go), Errors(No-Go), and Reaction Time.

3. Result

A multivariate analysis of variance was conducted with the group (Severe Paranormal Believers, Mild Paranormal Believers, and Skeptics) as the independent variable and the Go/No Go subscales scores as dependent variables. The MANOVA was significant that the differences between the means on the subscales are set out in Table 1. The findings show that there is a significant difference between the mean scores in Errors(Go) ($F_{2,89}=7.20$, $p=0.01$) , Errors(No- Go) ($F_{2,89}=11.81$, $p=0.01$) and Reaction Time ($F_{2,89}=21.46$, $p=0.01$) between the groups. In other words, the Severe Paranormal Believers and Mild Paranormal Believers had lower accuracy and slower RT than the Skeptics group. Therefore, severe paranormal believers and Mild Paranormal Believers had weakness in all Go/No-Go subscale scores.

Table 1. Task performance in groups.

	Group condition			MANOVA	
	Severe Paranormal Believers	Mild Paranormal Believers	Skeptics	<i>F</i>	<i>P</i>
Errors(Go)	0.077± 0.081	0.080± 0.066	0.026± 0.04	7.20	0.01
Errors(No- Go)	0.116± 0.121	0.026± 0.038	0.053± 0.03	11.81	0.01
Reaction Time	493.780± 88.266	406.431± 58.655	393.562± 49.841	21.46	0.01

Values are described as mean ± standard deviation.

Reaction Time in ms (milliseconds).

Figure 1. Error rate and reaction speed for Go/No-Go task. The figure above shows the error rate and reaction time for the skeptical, mild, and severe groups in the Go/No-Go task. The X-axis shows the different levels of the groups. The Y-axis also indicates the mean error rate and reaction time.

4.1. Discussion

This study aimed to investigate the Comparison of cognitive control in groups with severe, mild, and Skeptics Paranormal Beliefs in the Go/No-Go Task. The findings showed that there was a significant difference in cognitive control performance between groups in errors and reaction time. We can be according to these findings, and the severe paranormal believer has weak cognitive control. Therefore, previous studies with other tasks have shown that there was an inverse relationship between paranormal beliefs and inhibition. Thus, Wain and Spinella (2007) found that paranormal beliefs related inversely to inhibition control with the Executive Function Index (EFI). Another study has shown that believers than skeptics made significantly more errors on all subscales of the Wisconsin Card

Sorting Test (WCST) but were equivalent in performance on the Stoop task (Lindeman & Svedholm, 2012).

Whereas, B. M. Hood, Lindeman, and Riekkki (2011) and B. M. Hood et al. (2011) reported significant findings on paranormal believers' inhibition. Lindeman & Svedholm (2012) showed that paranormal believers had poor cognitive control performance based on the WCST. However, paranormal believers and skeptics cognitive control performance did not differ significantly in the Stroop task. According to previous studies on the performance of paranormal believers and skeptics in various tasks related to inhibition, different tasks for assessing inhibition do not show the same results. Therefore, it was necessary to use a different task than previous studies to assessing inhibition in paranormal beliefs. So, we used the Go/No-Go Task. This result in the present study differed from Stroop's performance in previous studies. The cause of these differences is not entirely exact. Perhaps one of the reasons is the greater sensitivity of the test Go/No-Go Task than the Stroop task of assessing cognitive control (Macatee et al., 2018). Also, there are conflicting results from in WCST, EFI and Stoop test on cognitive control (Dillon & Pizzagalli, 2007; Friedman & Miyake, 2004; Nigg, 2000). Therefore, we used the Go/No-Go Task to more directly cognitive assessment control. Using the Go/No-Go Task findings may be necessary to explain previous studies because the association of tasks such as Stroop and WCST with the inhibitory assessment is challenged (Dillon & Pizzagalli, 2007). Another reason for the differences in the tasks' results may be the complexity of cognitive control and its multidimensionality, making it challenging to evaluate. Besides, it may also refer to related but distinct concepts (Braver, 2012).

Previous findings also support the view that paranormal beliefs are related directly to cognitive control (Nigg, 2000). Although these findings are preliminary, they have an essential role in explaining the causes of the tendency for paranormal beliefs. Also, cognitive control weakness can be explained from many perspectives such as Neural, cultural, and cognitive. According to the neural perspective, Inhibition control is one of the essential mechanisms in humans closely related to

the DLPFC region(Hampshire, Chamberlain, Monti, Duncan, & Owen, 2010). This region may be involved in reducing paranormal beliefs by expanding cognitive control abilities.

According to the cultural perspective, paranormal beliefs form a broad set of beliefs that can exist directly or indirectly in individuals (Narmashiri et al., 2019). Paranormal beliefs appear to stem from other factors, such as culture. Cultural factors may underlie such different findings. However, there may be a tendency for paranormal beliefs to come from each region's particular culture. Since these differences are rooted in childhood (Preece & Baxter, 2000). Therefore, be reduced by training but seems to be related to inhibition that varies between individuals and varies with age. According to the cognitive perspective, the results supported the idea that cognitive inhibition or related cognitive control mechanisms function as a regulator of conflicts between intuitive and analytic thinking by downplaying intuitive biases associated with paranormal beliefs. B. Hood (2009) has proposed that paranormal beliefs may be latent and that they can re-emerge when inhibition is compromised. Thus, effective regulation of intuitions has an essential role in disbelieving.

We had several limitations in this study. Convenient sampling and selection of the sample from university students constituted one of the limitations of the present study. Further investigations with a larger population focusing on other variables related to cognitive inhibition are necessary. In addition, with regard to the participation of women in this study, some studies have reported that performance in cognitive tasks related to the prefrontal cortex might be affected by the levels of estrogen and progesterone hormones (Amin et al., 2006; Solis-Ortiz et al., 2004). Therefore, future studies are recommended to control the menstrual period of female participants.

5. Conclusion

In summery, our results showed that the paranormal believers had lower accuracy in Go and No-Go trials and slower RT than the Skeptics group. Therefore, paranormal believers had a weakness in all Go/No-Go subscale scores. This finding suggests that paranormal beliefs may related to poor cognitive control.

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Conflict of interest

The authors declared no conflict of interest.

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CRedit authorship contribution statement

Abdolvahed Narmashiri: Conceptualization, Methodology, Software, Writing - original draft, Writing - review & editing. **Javad Hatami:** Conceptualization, Methodology, Writing - review & editing, Supervision. **Reza Khosrowabadi:** Methodology, Software, Writing - review & editing, Supervision. **Ahmad Sohrabi:** Resources, Supervision.

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