

FINAL REPORT

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Title: “Using Neural Stimulation to Modulate Paranormal Beliefs”

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Right Inferior Frontal Gyrus

General Summary

We conducted two studies where we attempted to modulate paranormal belief via neural stimulation and a newly developed cognitive-style training programme. The rationale for these studies emerged from a growing literature connecting a high intuitive thinking style (and a low analytical one) to religious beliefs. In Study 1, we used transcranial direct current stimulation to the right inferior frontal gyrus and found that this was associated with a decrease in paranormal attributions and of implicit supernatural belief. These results suggest that increased cognitive inhibition is associated with decreased belief in the paranormal. However, we found no association between intuitive/analytical thinking style and paranormal beliefs. Study 2 developed a two-week novel training programme with the aim of increasing either intuitive or analytical thinking in two groups and testing whether such increase modulated paranormal belief. While this training had an effect on cognitive styles, neither group experienced changes in their levels of paranormal belief. Overall, the results of our two

attempts to causally test whether dual processing thinking underpinned belief suggest that paranormal beliefs are modulated by cognitive inhibition, but not intuitive/analytical thinking. These results have been written and submitted as two separate articles that are currently under revision.

Study 1: The neurostimulation of Paranormal Belief

Explanatory note: The report below follows from the first progress report but differs from it in two ways: (1) The initial study included 3 experimental conditions (anodal, cathodal, sham/placebo), while the final study only included 2 conditions (anodal *versus* sham); and (2) the initial study used a between subjects comparison (religious, atheist, and spiritual but non-religious participants) while the final study used a within subject analysis (not taking account of group religious affiliation). As explained in the progress report, we found no significant results for any of the outcome measures using the original design with a sample of 90 participants (30 per group). This led us to explore other methods of attempting to modulate paranormal belief via cognitive thinking style manipulation, which gave rise to Study 2. Concerning Study 1, we sought advice from neuroscientist colleagues, including one who pioneered the use of transcranial direct current stimulation for cognitive enhancement (Cohen-Kadosh), and they suggested reanalysing the original data using different parameters, including selecting participants that had shown sensitivity to the neural stimulation. The results of this new data analysis are reported below; the final sample of 44 participants was selected based on sensitivity to the stimulation on the Stop Signal task (i.e., reduced reaction times in the anodal session when comparing the results for before and during stimulation).

Study summary

Here we investigated the causal role of cognitive inhibition in the formation and endorsement of paranormal beliefs in a novel way by using non-invasive transcranial direct current stimulation (tDCS) to suppress or enhance activity in the right inferior frontal gyrus; this is an area which has systematically been shown to be involved in cognitive inhibition in a number of lesion and brain imaging studies (Aron et al., 2004). Thus, by using tDCS we aimed to reversibly modify cognitive inhibition and, consequently, the endorsement of supernatural beliefs in individuals. Our hypothesis was that enhancing cognitive inhibition by applying anodal transcranial direct current stimulation (tDCS) stimulation on the right inferior frontal gyrus (rIFG) would decrease paranormal beliefs.

Aim of the study

To test the causal relationship between dual processing styles, cognitive inhibition, and supernatural belief.

Participants

Forty-four participants (27 female) completed the neurostimulation study. They were members of the general public, of a variety of ages (age $M = 30.98$, $SD = 12.52$, range 18-60 years) and beliefs (36.4% Christian, 22.7% atheist, 18.2% spiritual but not religious, 18.2% agnostic, 4.5% spiritualist).

Methods

We used transcranial direct current stimulation (tDCS) to the right inferior frontal gyrus in a double blind trial (neither experimenters or participants were aware of the stimulation

condition). The participants completed a number of tasks: a standard task of cognitive inhibition (stop signal task) and two tasks to measure levels of paranormal and supernatural beliefs (paranormal attribution task and the implicit association task with religious/spiritual stimuli). They also filled in a standard measure of dual processing thinking (Cognitive Reflection Task).

Results

Please see an overview of the results in Table 1 below.

Task	Measure	Stimulation type		<i>p</i> -value
		Anodal	Sham	
Stop Signal Task	<i>msec</i>	208.18 (45.13)	233.56 (62.73)	.01*
Paranormal Attribution Task	<i>n</i> <i>attributions</i>	3.30 (1.65)	3.44 (1.60)	.05*
Religious/Spiritual IAT	<i>D-score</i>	0.34 (.39)	0.32 (.42)	.03*

Table 1: Difference between the Anodal and Sham condition during stimulation sessions, means and standard deviations (M/SD) with reported ANOVA statistics.

For the Stop Signal Task, participants were significantly faster during stimulation in the anodal condition than in the sham condition. In the supernatural attributions task, there was a significant decrease in paranormal attributions during anodal ($M = 3.30$, $SD = 1.65$) stimulation relative to sham ($M = 3.44$, $SD = 1.60$) stimulation, $F(1,42)=3.94$, $p=.05$. In the implicit association task, the participants scored significantly higher under anodal stimulation

($M = .34$, $SD = .39$) than under sham stimulation ($M = .32$, $SD = .42$), $F(1,42)=5.28$, $p=.03$. That is, anodal stimulation decreased the tendency to associate religious/spiritual stimuli with the category 'real.' Results on the Cognitive Reflection Task did not correlate with paranormal attributions under Anodal or Sham stimulation ($r's < -.03$, $p's > 0.57$), nor with the implicit association task scores ($r's < .02$, $p's > 0.71$), or with religiosity ($r=.11$, $p=.47$), or spiritual practices ($r=.14$, $p=.38$).

Conclusions

By applying brain stimulation to enhance cognitive inhibition, a process previously suggested to down-regulate supernatural belief, we observed changes in two belief measures. This study was the first to demonstrate a causal relationship between cognitive inhibition and the modulation of paranormal and supernatural beliefs. On the other hand, we found no association between a standard test of dual processing thinking and any of the belief measures.

Note: For further details see attached manuscript under review, Study 3.

Farias, M., van Mulukom, V., Kahane, G., et al (under review). Supernatural belief is modulated by cognitive inhibition, not intuition. *Scientific Reports*.

Study 2: A training programme on cognitive thinking style and its effects on paranormal belief

Study summary

Previous research on the interaction between cognitive styles and religiosity has shown that increased analytical thinking is linked to decreased religiosity. However, there are virtually no studies that have attempted to increase intuitive thinking to test if this thinking style underpins paranormal beliefs.

The purpose of this study was to develop a newly designed intervention to increase participants' intuitive or analytical thinking (their ability to use intuitive thinking or analytical thinking, as well their levels of trust in the capacity to do so). The second aim of the study was to test whether increases in either thinking style would affect levels of paranormal beliefs. Over two weeks, participants were either asked to explore their feelings about a number of situations and artworks in a systematic way (intuitive thinking), or to think about them carefully and analyse the situations and artworks (analytical thinking). After the two-week intervention, we measured whether levels of intuitive and analytical thinking had increased, and if levels of paranormal belief had changed concurrently.

Aim of the study

The purpose of this study is to run a newly designed intervention to increase participants' intuitive or analytical thinking and to test whether enhancing intuitive thinking strengthens paranormal beliefs.

Participants

Fifty-six participants (39 female) completed the training. Participants were recruited through flyers on the university campus of a British university. The participants were randomly allocated to either of the two groups: the intuitive group had 29 participants; the analytical group had 27 participants.

There were no significant differences between the groups for gender, age, or belief system.

Methods

The training spanned two weeks and included two assessment sessions and six training sessions, as well as four journal sessions. The pre- and post-training session lasted for one hour each. These assessments took place immediately before and after the two weeks of training. The assessment sessions included measures of cognitive style and paranormal/supernatural belief.

Training sessions took place three times a week for two weeks, each half an hour long. Training sessions involved three tasks, adapted for each group (analytical, ANA, or intuitive, INT). On each training day participants completed three tasks: (1) A reading task where they read a scientific text that either promoted analytical (ANA) or intuitive (INT) thinking; (2) A Creativity task where they engaged either with paintings, pieces of music, or stories, and asked to think about (ANA) or feel (INT); (3) A focus task where they were asked to imagine a situation which outcome would be determined by thinking (ANA) or feeling (INT). In addition, the participants completed a journal task twice per week for the duration of the training. In this journal, participants were asked to write down any events of that week in which thinking (ANA) or feeling (INT) helped them resolving a situation.

The pre- and post-training assessment session included tasks to measure thinking style (REI scale, reversed REI scale, Ambiguous Decisions task, cognitive reflection test, base-rate

task) and to measure supernatural belief (Supernatural Belief Scale, Psychic Ability Scale, Paranormal Beliefs Scale).

Results

In the main analysis, we assessed changes in cognitive styles measures as a consequence of the training by comparing pre- and post-training scores between groups. Over the course of the training preference for intuitive thinking in participants of the intuitive group increased significantly ($p=.03$), with a trend for increase in trust in intuitive thinking ($p=.07$). Moreover, participants indicated they would rely significantly less on analytical thinking ($p=.05$) and significantly more on intuitive thinking ($p<.001$) in the ambiguous decisions task. For the analytical thinking group, preference for and trust in analytical or intuitive thinking did not change significantly, but participants indicated they would rely on analytical thinking more ($p<.001$) and intuitive thinking less ($p=.001$) in the ambiguous decision task as compared to the pre-training assessment.

To investigate whether the effects of the training differed between groups, on cognitive style measures and paranormal beliefs, we ran ANOVAs on the difference scores, calculated by subtracting the pre-training from the post-training scores. We found that the training impacted participants' preference for and trust in intuitive thinking differently, but not for preference for and trust in analytical thinking. Moreover, the training influenced participants' choices on the ambiguous decision task differently (with large effect sizes), but there were no differences for the effects of the training on other behavioural measures of cognitive style, or on paranormal belief.

Conclusion

The novel cognitive style training had an effect on people's trust in, and preference for, intuitive thinking: these scores increased in the intuitive group and decreased in the analytical group. No other significant differences in behavioural measures of cognitive style as a result of the training were found.

We found no differences in supernatural beliefs as a result of the training for either cognitive style. This adds further evidence to recent correlational studies and our first study that also failed to find an association between cognitive style and supernatural beliefs.

Note: For further details see attached manuscript submitted for review, Study 2.

van Mulukom, V., Maraldi, E. Jong, J., & Farias, M. (submitted). Does cognitive style training impact supernatural beliefs? A causal test of the Intuitive Belief hypothesis. *Consciousness and Cognition*.