Unveiling the Mystical Nature of the Placebo God Helmet: Comparing Placebo-Induced to Naturalistic Mystical Experiences

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Abstract

This study investigated whether suggestion and placebo effects can induce mystical experiences using the God Helmet, a placebo brain stimulation device. Seventy-nine participants wore the placebo God Helmet for 45 minutes in sensory deprivation and were interviewed about their experience. A qualitative analysis showed that, although participants reported unusual experiences, these were distinct from their previous mystical experiences. Additionally, a permutation analysis revealed that participants rated the intensity of the God Helmet experience lower on average than their previous mystical experiences, suggesting that the God Helmet experiences are less intense. Nevertheless, the experiences induced by the God Helmet were reported as stronger than normal daydreaming and shared similarities with hypnagogic (falling asleep) states. In addition, a regression showed that individuals with more previous mystical experiences had more unusual experiences with the God Helmet and a higher Mysticism scale score, highlighting the importance of considering individual differences for understanding sensitivity to mystical-type experience. Although most participants did not have a mystical experience with the God Helmet, an explorative analysis showed that those who did score highly on the Mysticism scale also had a higher follow-up score on the Flourishing scale, showing that placebo-induced mystical experiences also have long-term positive wellbeing changes. As the God Helmet shows potential for inducing hypnagogic states within a 45-minute session, it has potential applications in sleep research and provides new avenues for investigating altered states of consciousness. However, the God Helmet does not induce authentic mystical experiences in most participants, and therefore is not an effective tool for investigating mystical experiences or applying them for therapeutic purposes.

Introduction

Mystical experiences are unique states of consciousness in which one has an experience of unity, insight, and finds the experience difficult to put into words (i.e., ineffability). Other elements are sacredness, transcendence of time and space, paradoxicality, and positive emotion, which were altogether defined by Stace (1960) as the seven dimensions of mystical experience. These dimensions have been used to develop questionnaires, such as the Mysticism Scale by Hood (1975) and the Mystical Experience Questionnaire by Pahnke (1963), to measure the extent to which an experience is considered mystical. These questionnaires assume that mystical experiences have a "common core," that is, that there are reoccurring elements across all mystical experiences. This is in contrast with a constructivist approach, which would suggest that mystical experiences are unique and shaped by individual perspectives, prior knowledge, and interactions with their environment.

Several contexts can trigger these experiences, including meditation (e.g., Russ & Elliot, 2017), psychedelics (e.g., Griffiths et al., 2011), spiritual contexts (e.g., Nusbaum & Thisted, 2010), and significant life events (e.g., near-death experiences, Woollacott & Shumway-Cook, 2020), but they can also occur spontaneously, for example during a walk in nature (Williams & Harvey, 2001). Several studies have shown that mystical experiences strongly impact people's lives and are linked to positive changes in one's attitude, mood, and behavior (Griffiths et al., 2006). For example, participants report increased personal well-being and life satisfaction, increased positive affect, change in values, greater compassion and concern for others, and disidentification from maladaptive thinking and behaviour patterns (Garcia-Romeu et al., 2015; Griffiths et al., 2006). These positive effects can last weeks and months following the experience (Barrett et al., 2015; Griffiths et al., 2006; Griffiths et al., 2008; Griffiths et al., 2011).

Next to the contexts explained above, mystical experiences can be evoked through suggestion and placebo effects, for instance with a placebo brain stimulation device called the God Helmet. In this paper, we will examine the extent to which the experiences induced by the God Helmet share similarities with mystical experiences induced in other contexts.

God Helmet

The God Helmet originated as a brain-stimulation device built by Michael Persinger (Cook & Persinger, 1997) that used weak magnetic fields to stimulate the temporal lobes. Persinger aimed to induce a sensed presence, a manifestation of a mystical state (Persinger et al., 2009), by imitating brain patterns observed in people who felt a presence that was not physically there. While initial studies using the God Helmet showed promising results, 10 out of 15 participants reported a sensed presence that correlated with the magnetic field pulses, a later double-blind study by Granqvist et al. (2005) found no effect of the magnetic fields. Instead, they attributed the reported mystical experiences in the earlier study to suggestibility, due to priming with questionnaires on religious and supernatural beliefs in the experimental set-up, and a possible effect of sensory deprivation while wearing the helmet.

After this, other researchers used the God Helmet as a suggestion-enhancing device, using random weak magnetic fields (Andersen et al., 2014) or no magnetic fields at all (van Elk, 2015; Maij & van Elk, 2018; Maij et al., 2019). Indeed, participants in these experiments still reported unusual and even mystical experiences. In the study by Andersen et al. (2014), almost half of the participants reported a sensed presence (either visually, by touch, or by a general feeling, e.g., “I sensed a masculine energy,” “I could clearly see his facial features”), and 78% had some kind of unusual experience (e.g., bodily sensations, visual elements, “All of a sudden I saw planets that flew past me”). In the study by Maij & van Elk (2018), 48% reported having extraordinary experiences with the God Helmet (e.g., “I felt an energy around my eyes and my eyes started pounding… At a certain moment, everything in the surrounding started to spin, shake and move. It made me really dizzy…”).

The God Helmet studies have documented various unusual experiences, such as dizziness, sensed presence, tingling sensations, vivid images, vibrations, and out-of-body experiences. While some participants in these studies have scored highly on mystical experience questionnaires after using the God Helmet, it is worth noting that these experiences are varied and may be caused by several mechanisms, as discussed in the following section.

Mechanisms Explaining the God Helmet Experiences

Different mechanisms can account for the effects observed with the God Helmet, including suggestion and placebo effects. By creating a suggestive context (e.g., telling participants the God Helmet will stimulate their brain and what effects they should expect), participants can experience a placebo effect (e.g., have an extraordinary experience that cannot be attributed to the effects of the helmet on the brain). Many factors influence the placebo response, like expectations, personality, suggestibility, and the psychological state of the recipient, as well as the physical setting in which the placebo is administered (Hartogsohn, 2016). The elements of physical setting and psychological factors have been named "set and setting" in psychedelic research, as they also play a significant role in the psychedelic response.

The effects of the God Helmet can also be explained by the sensory deprivation context, as participants who try the helmet are blindfolded, listen to white noise, and sit still for a prolonged period. Sensory deprivation elicits unusual bodily sensations and hallucinations in other contexts as well, such as in a floating tank (Kjellgren et al., 2008). During a 45-minute floating tank session, it is common to experience a mildly altered state of consciousness with mental imagery, changes in perception and body image, and an altered sense of time. In addition, and similarly to the experiences reported with the God Helmet, the floating tank can sometimes evoke mystical-type experiences, such as out-of-body experiences and encounters with other beings (Kjellgren, 2003; Kjellgren et al., 2008).

Indeed, Andersen et al. (2014) and van Elk and Alemán (2017) attribute the effects of the God Helmet to a combination of suggestive context and sensory deprivation, clarifying this with the predictive processing framework. Predictive processing explains brain functioning in terms of predictions, sensory input, and updating: the brain generates mental models of the environment, creates predictions based on these models, and then updates the predictions based on sensory input. When there is a mismatch between the prediction and the sensory input, there is a prediction error that updates the old model to fit the new information (Clark, 2013; Fistion & Kiebel, 2009).

Because perception is based on expectations (i.e., predictions), this makes information processing efficient but also prone to error (Corlett et al., 2018). When there is limited sensory input, as in a sensory deprivation context, there is limited bottom-up processing against which the predictions can be checked, and predictions influence experience strongly. In the case of the God Helmet, participants have (strong) predictions about their future experience with the helmet, such as perceiving hallucinations or having mystical experiences. These predictions, combined with the blindfold and white noise that reduce sensory inputs, will influence participants' experience. In line with this, participants who believe in the manipulation have more unusual experiences (van Elk, 2015), likely because they have a stronger expectation of experiencing something unusual.

Alternatively, induced suggestions in combination with the sensory deprivation context may result in a relaxation of prior beliefs. The REBUS model proposes that mystical experiences arise when prior beliefs and expectations are relaxed, allowing for a more open and flexible state of mind (Carhart-Harris & Friston, 2019). In the context of God Helmet studies, participants have expectations about the potential effects of the God Helmet, but they may also be more willing to suspend their beliefs and adopt a more open and curious attitude towards the experience. This could facilitate the processing of new information and increase the ability to generate novel predictions and interpretations of sensory input. In addition, the sensory deprivation context created by the God Helmet reduces external sensory input, resulting in less information that can help to accurately weight the reliability of the incoming sensory signals. In other words, the precision of sensory evidence decreases, as there are fewer other sensory channels to compare new sensory signals against. As a result, the sensory signals that do come through get assigned excessive weight, reaching consciousness without being filtered or distorted by pre-existing beliefs and expectations. In this way, the sensory deprivation context may reduce top-down bias (i.e., the priors), allowing for a more open and flexible state of mind in which sensory input, both interoceptive and exteroceptive, may be assigned excessive weight, contributing to the emergence of unusual experiences. For

example, a tingling sensation originating from within the body may be perceived as having an external source due to the lack of visual confirmation.

Another potential explanation for the intensity of the experiences reported in God Helmet studies is social desirability responding or demand characteristics, in which participants may exaggerate their experiences to match the experimenter's expectations (Nederhof, 1985). While Maij et al. (2018) argued that the level of detail in the reported experiences indicates they are not confabulated, this does not necessarily indicate that the experiences were mystical. For example, a detailed dream can be viewed as ordinary, yet the same dream could be perceived as highly unique if expressed differently.

In addition, paying attention to mental imagery and bodily sensations in the context of a study may also make the experience with the God Helmet stronger or more unusual. Maij and van Elk (2018) proposed that participants attribute extra meaning to random mental imagery and thoughts because of the suggestion that they are experiencing brain stimulation, resulting in unique or unusual experiences. Indeed, participants report experiencing auditory, visual, and mental sensations while wearing the helmet (Maij et al, 2018; Maij & van Elk,2018). However, during normal daydreaming and mind-wandering, it is also usual to have mental imagery, perhaps an auditory sensation of one's internal voice, and even emotions corresponding to the tone of thought. In contrast, hallucinations are self-generated perceptions that are experienced as if they are from an external and real source (Bentall, 1990). It has been hypothesized that hallucinations are a more intense form of mind-wandering (Fazekas, 2021), where the sensory elements are amplified, but it is unknown where the sensations reported with the God Helmet are located on the spectrum of normal daydreaming to hallucinations.

These possible mechanisms question whether the experiences with the God Helmet are truly mystical or perhaps ordinary experiences that are interpreted or expressed in a way that makes them seem mystical. Therefore, in this study, I want to examine the experiences with the God

Helmet more closely to determine to what extent mystical experiences can be evoked through suggestion methods.

Current study

As previously discussed, participants' expectations about the God Helmet likely influence their experience. Given that predictions are based on prior experiences, the experiences participants have with the God Helmet may be related to their previous mystical experiences. Indeed, several participants have compared their experience with the God Helmet with their past mystical experiences (Maij & van Elk, 2018; Maij et al., 2018). Likewise, Andersen et al. (2014) found that participants who reported more unusual experiences with the God Helmet rated their experience as more similar to previous spiritual or mystical experiences. Therefore, in this research, we aim to study to what extent participants' experiences with the God Helmet are related to their previous mystical experiences.

Furthermore, it is unclear whether the experiences with the God Helmet can be classified as mystical experiences. Researchers have loosely used the term "mystical" in the God Helmet literature. For example, Andersen et al. (2014) defined mystical experiences as "perceptions embedded in a religious or spiritual framework, which are caused by a dominance of the brain's internal models" and categorized them under "unusual experiences." In this sense, mystical experiences do not require elements of unity, ineffability, or transcendence of time and space. Indeed, their study asked participants to indicate when they had an "unusual" experience, not a mystical one. Moreover, Maij and van Elk (2018) introduce the God Helmet as a device that can elicit "mystical and quasi-mystical (i.e., extraordinary) experiences." The term quasi-mystical indicates similar elements between unusual or extraordinary experiences and mystical experiences, but we still need to clarify to what extent these unusual God Helmet experiences are mystical. In this study, comparing the experiences with the helmet to previous mystical experiences will allow us to see whether the experiences with the helmet are as intense and extraordinary as other mystical experiences are.

To further establish the validity and authenticity of the experiences reported with the placebo God Helmet, we will examine whether the God Helmet has any long-term effects on wellbeing, similar to what was found for mystical experiences induced by psychedelics (e.g., Barrett et al., 2015; Carhart-Harris et al., 2021; Griffiths et al., 2006; Griffiths et al., 2008; Griffiths et al., 2011). In addition, we will ask participants compare the God Helmet experiences to daydreaming and imagination, as it is unclear whether the sensations reported by participants while using the God Helmet are distinct from ordinary imagery that occurs during these states.

Hypotheses

The first aim of this pre-registered study (for the pre-registration report, see https://osf.io/sq4zr), is to assess to what extent prior mystical experiences influence the experiences with the God Helmet. For this, I want to test whether the number of prior mystical experiences has any influence on participants' experience with the God Helmet by testing the following hypothesis:

1. *Participants with more previous mystical experiences will have more and/or more intense experiences when presented with a placebo God Helmet procedure, compared to participants with fewer previous mystical experiences.*

The second aim of this study is to investigate whether mystical experiences as triggered through the God Helmet are comparable in intensity and quality to authentic previous mystical experiences (e.g., as triggered through meditation or psychedelics). For this purpose, I will test the following hypothesis:

2. *Participants will judge the experience with the God Helmet to be similar to their previous mystical experiences regarding strength/intensity and quality/content of experience.*

Lastly, to further validate the extent to which experiences with the God Helmet are authentic mystical experiences, I will compare the experiences with the God Helmet with normal daydreaming and imagination in the following hypothesis:

3. *Participants will judge the experience with the God Helmet to be different from daydreaming and imagination in terms of strength/intensity and quality/content of experience*

In addition to testing these pre-registered hypotheses, I will conduct two non-confirmatory analyses. First, I will conduct an exploratory analysis to see whether the God Helmet has long-term effects. Second, I will explore whether social desirability influences the results.

Method

Design

This study has an individual difference approach and uses a cross-sectional design with both within-subject and longitudinal elements. The study does not have a control condition (i.e., a condition in which participants are instructed that the helmet is switched off or are not provided with a helmet at all) - all participants followed the same procedure, in which they were instructed that the helmet would be turned on and that this may trigger mystical-type experiences.

The reason for having no control condition is that previous research by van Elk (2015) found that instructions regarding whether the helmet was turned on or off were not effective. Instead, whether the participants *believed* that they were in the helmet on or off condition (i.e., how skeptical they were) was influential for their experience. In addition, telling the participants about the multiple conditions increased skepticism. Furthermore, by having no control condition, it was feasible that participants spent a long period with the God Helmet on, increasing the chance that they would experience something mystical (Andersen et al., 2014).

To increase suggestibility, we told participants that the strength of the helmet stimulation varies over time, which allowed participants to attribute their lack of unusual experiences at certain times to the helmet producing weak magnetic fields, adding to the credibility of the manipulation.

Participants

Power analyses using G*Power (Faul et al., 2007) indicated a sample size of 78 participants would be needed to detect a medium effect size of 0.15 (see Appendix A for the calculations for each analysis). Rounding this upward to account for eventual dropout or missing data, 80 males and females aged between 18 and 45 were recruited. Inclusion criteria were the ability to read English and speak either English or Dutch.

As this study aimed to determine to what extent the God Helmet can induce mystical experiences, we selected a sample that would be able to compare the experience with the God Helmet to previous mystical experiences. Therefore, the recruitment flyer explicitly stated we were looking for participants with interests in meditation, psychedelics, spirituality, and/or earning money. This last category was included to also attract participants with no background in the other three categories.

To increase suggestibility, participants were told they could not participate if they had a history of neurological disorders or head trauma and if they used any drugs one week or less prior to participation. To minimize the chance of recruiting participants who may be skeptic about the helmet manipulation, psychology or medicine students were excluded. Lastly, to increase the quality of fEMG signals, participants were excluded if they were taking any medication that might affect emotional functioning or if they had Botox injections in the face.

Participants were recruited via targeted Facebook and Instagram advertisements and by flyers left in university buildings, smart shops, coffee shops, and yoga and meditation studios in Leiden (The Netherlands). Participants were paid 10 euros per hour. Ethical approval was obtained by Leiden University's Psychology Research Ethics Committee (CEP).

Procedure

Participants signed up via an online questionnaire, which included the information brochure of the study and an online informed consent form. After signing the consent form, participants were redirected to a second online questionnaire, which included several screening questions (see Figure

2). As this study was part of a larger project, not all these questionnaires and measures taken were used in the current study. For the detailed procedure and measures, see Appendix B.

After filling in these questionnaires, participants were invited to a lab session scheduled at least two weeks later to avoid carry-over effects. At the lab, participants were shown a short video defining the characteristics of a mystical experience and were briefly interviewed about their prior mystical experiences and their beliefs associated with mystical experiences. After this, we placed facial electromyography (fEMG) electrodes on the participants and showed a video[1] introducing the God Helmet as a brain-stimulation device that has been used to induce mystical experiences by stimulation of the temporal lobe. Due to COVID-19 measures, the experimenters always wore a surgical face mask during the session.

To minimize the chance that participants would find out that the God Helmet works through placebo effects (for example, by online searching), we called it a 'brain stimulation helmet' in the online information letter. In the lab session, we called it the 'Persinger Helmet' to be able to include parts of existing high-quality explanation videos to increase credibility and suggestibility.

After watching the video explaining the God Helmet, the participant put on a blindfold and the helmet. We then recorded a baseline, asking the participant to count in their head from 0 to 100 and press with increasing strength at 20, 40, 60, 80, and 100, with the last press being as strong as they expected to press when they had a very intense experience.

We then plugged in cables from a fake amplifier to the helmet and told the participant that the helmet would be turned on from outside the room at the same time as the white noise was turned on (note: the helmet was never turned on and was not attached to electric currents). Participants then lay for 45 minutes wearing the God Helmet and an eye mask while they listened to white noise through speakers mounted inside the helmet. Participants were instructed to press a

[1] This video included parts of researcher Susan Blackmore's explanation of her experiences with the Persinger Helmet, taken from: https://www.youtube.com/watch?v=DBI9Ms_HEZ0

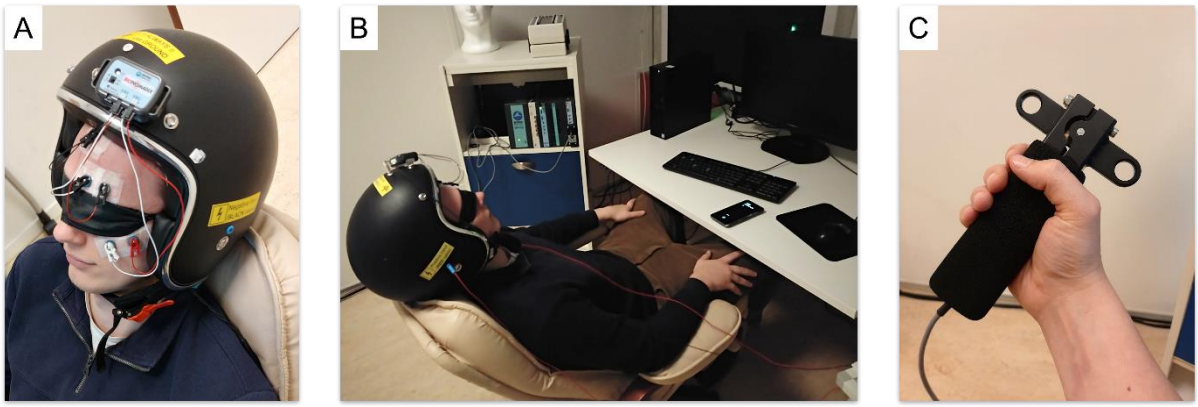
handheld gripper (see Figure 1C) after every unusual experience and were able to indicate the strength of their experience by gripping lighter or stronger.

After the experimental session, we asked participants about their experience with the helmet in a semi-structured interview. After the interview, participants filled in another online questionnaire at the lab (see Figure 2 and Appendix B), including the 32-item version of the Hood's Mysticism Scale (M-scale; Hood, 1975).

Lastly, participants filled in a questionnaire one day, one week, and one month after the experimental session to assess to what extent their view on their experience with the helmet had changed. The questionnaire on the last time-point (one month after the session) included a manipulation check to see whether participants were skeptic or had researched the helmet after the session. It also included the debriefing.

Figure 1

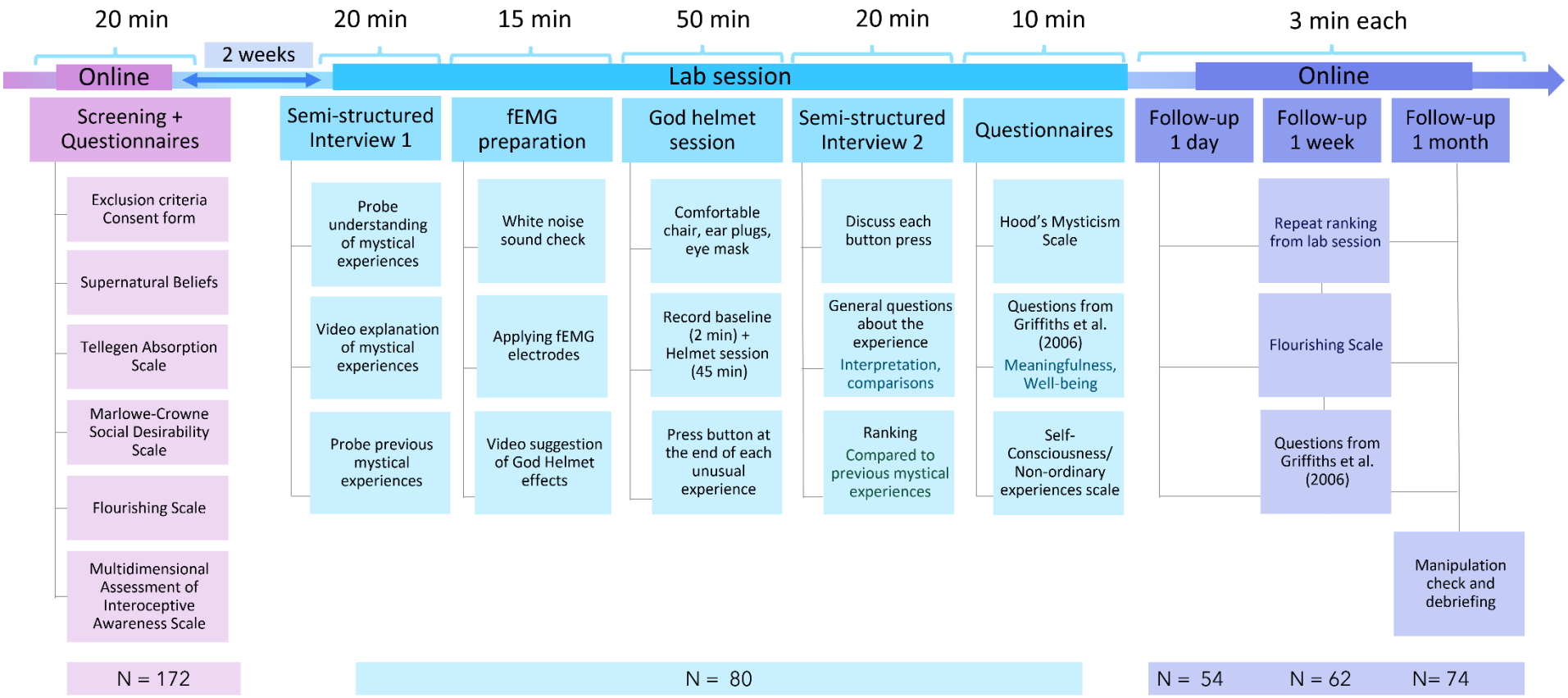
Participant During the Helmet Session



Note. (A) Shows the helmet, fEMG electrodes, wireless receiver, and folded eye mask. (B) Shows the participant on the reclinable chair, which is adjustable to maximize comfort. (C) Shows the handheld gripper participants pressed after they experienced something unusual. The strength of the grip could be varied to express a strong or mild experience.

Figure 2

Full Study Design. The measures analyzed in this paper are marked with a square frame.



Note. Participants filled in an online questionnaire and were then asked to come to a lab session scheduled at least two weeks later. After the lab session, participants received follow-up questionnaires via e-mail, the last of which included the debriefing for the study.

Measures

As the current study is part of a project involving two other master's students, not all the variables measured in the sessions are relevant to the current study. Below, I only describe the relevant measures. A full description of all measures used can be found in the Appendix B and in the Open Science Framework pre-registration of this project (https://osf.io/sq4zr).

Hood's Mysticism Scale

This scale measures whether a specific experience was mystical. It has 32 items (Hood, 1975), answered on a 5-point scale (1=strongly disagree, 5=strongly agree), and has a high reliability score (α = .95, Streib, Klein, Keller, & Hood, 2021). Participants filled in this scale after the second interview during the lab session using Qualtrics (https://www.qualtrics.com).

Experience strength

Participants were instructed to press a gripper (BIOPAC Hand Dynamometer 100 kg) every time they experienced something unusual with the God Helmet. Participants were asked to press the gripper after their experience had ended and were able to indicate the strength of their experience by gripping lighter or stronger. For this measure, we used the strongest press during the experiment, re-scaled to account for individual differences in strength. We calculated the re-scaled value by dividing the strongest press during the experiment by the strongest press during the baseline:

$$max_{scaled} = \frac{max_{experiment}}{max_{baseline}}$$

Number of unusual experiences

After the helmet session, participants were shown a plot with the gripper presses they made with the gripper while they were wearing the God Helmet. Participants were asked to explain what they experienced during each gripper press. We then counted the gripper presses that participants could remember executing and used that as the number of unusual experiences, to account for erroneous gripper presses. However, as participants may also have erroneous recall of gripper presses, we did a second count using a threshold (3 SD from the mean) to check for robustness. The

analysis for hypothesis 1 was performed twice, once with the threshold approach and once with the counting approach.

For the counting approach, we only counted the gripper presses that participants could remember well enough to explain what had happened during that gripper press. During data collection, we noticed that some participants pressed multiple times for the same type of experience, either when the experience reoccurred or when the experience became stronger, while others only pressed once for each type of experience. We therefore decided that when participants pressed multiple times for the same experience, we would count this as only one experience in this method.

For the threshold approach, we excluded data from participants who reported having no gripper presses, as this approach would otherwise find gripper presses that were only noise, and it is unlikely that a participant would erroneously recall having no gripper presses. In addition, some participants reported misunderstanding the instructions and pressing at the beginning and the end of each experience. Before analysing the data, we decided to include these participants in the data analysis, but to divide the number of presses from the threshold count in half. However, when participants did not press at the beginning and the end of each experience but did press multiple times for the same experience (as explained in the counting approach), all presses were counted.

We recorded the data from the gripper using the Acqknowledge software (Kremer, Macy, Findlay, & Peterlin, 2007) and pre-processed data with the Physiodata toolbox (Sjak-Shie, 2022), using a lowpass filter of 10 Hz and a highpass filter of 1 Hz. We chose these filters because they performed best for participants that had clear presses. While inspecting the number of presses with the threshold approach and the counting approach, we noticed that the threshold approach sometimes had unrealistically high amounts of presses (e.g., 35-50 presses while participants reported only 8 or 9). We therefore chose to deviate slightly from the preregistration and to square the gripper values to distinguish better between presses and noise. These squared values were also

used for calculating the strongest press during the experiment and baseline, used to calculate the experience strength (see above).

Custom-made items

Number of previous mystical experiences. Participants wrote their top 10 mystical experiences prior to the God Helmet session, as an answer to the following question:

> *Here are some keywords describing the experiences you just talked about. Please think of any other mystical experiences you've had, assign a keyword, and rank them together with the ones we talked about from most intense or extraordinary to least intense. If you have had many mystical experiences, please write your top 10.*

God Helmet rank. Participants placed the God Helmet in their previously made ranking of their top 10 mystical experiences. They chose the position based on whether the God Helmet experience was more or less intense compared to their previous mystical experiences (see item below). This item was measured through Qualtrics in four instances: right after the God Helmet session, and one day, one week, and one month after the session.

I. *Here is the list of mystical experiences you filled in at the beginning of this session. Please think of where in this list you would place your experience with the helmet and place it there.*

Semi-structured interview. Participants were interviewed about their experiences with the God Helmet using a semi-structured interview (see Appendix B). Three questions in this interview included a 1-5 scale, and the scores for these questions were analysed. To make sure the participants understood the question and the scale correctly, we first asked them as open questions, and then showed the 1-5 scale and asked for a rating, after their open answer. The custom-made items are the following:

II. *"How much do you think the experiences are comparable?"* (Comparing previous mystical experiences with the experiences with the God Helmet)

III. *"Think of yourself daydreaming, for example when you get lost in thoughts or you are lost in imagination. Were the experiences with the helmet similar to that?"*

Both scored as follows:

1. Not at all, they were completely different
2. There may have been some similarities, but I'm not sure
3. Slightly comparable, there were a few similarities
4. Very comparable, the experience reminded me of the other
5. Identical, I felt like I was reliving a previous experience

IV. *"How strong or intense was the experience with the helmet compared to daydreaming?"*

Scored as follows:

1. Much weaker than daydreaming
2. A bit weaker than daydreaming
3. The same as daydreaming
4. A bit stronger/ more intense than daydreaming
5. Much stronger/more intense than daydreaming

Analyses

Qualitative analysis

To understand what type of experiences participants have with the God Helmet, I conducted a qualitative coding analysis of the interview data. After transcribing the interviews, I grouped the paragraphs of each participant's transcript that pertained to the same experience. To find common themes in participants' experiences, I then coded the transcripts using Atlas.ti (2021) software. I used a bottom-up approach, assigning concise codes to each unique element of the experience. To ensure comprehensive categorization, I then grouped similar elements together and recoded them with a code that captured these shared experiences. For example, I grouped sensations in the body according to their body part (e.g., hands feeling, chest feeling) and grouped similar sensations (e.g.,

"pins and needles" was merged with "tingling"). See Appendix C for a frequency table of the final codes used.

While coding the data, I noticed that most participants started by giving a general description of their experience. I chose to code this general description as well, making that code distinct from the more specific descriptions, allowing for an estimation of the overall feeling of the experiences.

In addition, when participants described their unusual experiences with the helmet, they sometimes compared them to other experiences like meditation, sleep or drugs. As I am also interested in the comparison of the God Helmet experiences with other ordinary and extraordinary experiences, I decided to make a distinct code for those parts as well and present them separately from the answers given later, when asked specifically whether the God Helmet experiences were similar to previous mystical experiences they had.

Lastly, I selected representative quotes for each category based on their similarity to other quotes in the group and their informativeness. When needed, I included a second quote to highlight significant differences between quotes in the same category.

Multivariate linear regression

To test Hypothesis 1, namely whether the number of prior mystical experiences is related to the number and strength of experiences with the God Helmet, a multivariate linear regression was conducted in R 4.2.0 (R Core Team, 2022) using the lm() function. In this analysis, the predictor was number of previous mystical experiences (Previous ME), and the four outcome variables were number of unusual experiences with the counting approach (Counting), number of unusual experiences with the threshold approach (Threshold), strength of gripper presses (Strength), and M-scale Score. As this hypothesis would be confirmed if there is a positive relation between prior mystical experiences and any of the dependent variables, I used a Bonferroni correction so that $\alpha = 0.0125$.

The variable *number of previous mystical experiences* was capped at 10, as participants filled in their ten strongest mystical experiences. Nonetheless, this variable was used as an interval variable.

I did not include age and gender as covariates in this analysis, as a multiple regression with four predictors would need a higher sample size than what is feasible in this study (the necessary sample size would be N = 114 for a medium effect size $f^2 = 0.15$ and power = 0.8, but the effect size may be smaller).

Permutation analysis

To test Hypothesis 2, namely whether the experience with the God Helmet is similar to previous mystical experiences, I analysed how the God Helmet experience was ranked among other previous mystical experiences in terms of the intensity of the experience. In particular, I tested whether the God Helmet experience was ranked among two other mystical experiences, as this would indicate the God Helmet experience is similar in intensity to the others.

For this, I conducted a permutation analysis in R (see Appendix D for the R script). I first calculated the mean rank of the God Helmet for all participants. Then, I shuffled the ranks for each participant and calculated a new mean rank of the God Helmet. I repeated this process 10.000 times and plotted a distribution with these 10.000 means from shuffled ranks. I then compared the original mean rank of the God Helmet (the one acquired from the data without shuffling) with this resulting (normal) distribution to test whether it falls in any of the distribution tails.

As participants who have had multiple previous mystical experiences would have larger weight in the permutation analysis than participants with only a few previous experiences, I normalised the ranks by calculating the proportional position of the rank relative to the total ranks given by a participant. Therefore, the position of the helmet was quantified as follows:

$$rank = \frac{rank_{helmet}}{rank_{total}}$$

That is, a participant who ranks the God Helmet in position 3 out of 5, will result in a God Helmet rank of 3/5= 0.6 (instead of 3). Participants who did not report previous mystical experiences were excluded from this analysis.

One-sample median tests

To see whether the experiences with the God Helmet are comparable to previous mystical experiences (Hypothesis 2) and to daydreaming or imagination (Hypothesis 4), I performed three separate one-sample median tests with the three 1-5 scores obtained from the custom questions in the interview (see *Custom-made items* above). Specifically, I looked at:

1. Whether the median of the sample is higher than 3 (that is, 4 or 5) in the question "*On a scale from 1-5, how much do you think the experiences are comparable?*" (Scored 1=not at all, 5=identical; see **Semi-structured interview** section above). This relates to Hypothesis 2.
2. Whether the median of the sample is lower than 4 (that is, 1, 2, or 3) in the question "*Think of yourself daydreaming, for example when you get lost in thoughts or you are lost in imagination. Were the experiences with the helmet similar to that?"* (Scored 1=not at all, 5=identical). This relates to Hypothesis 3.
3. Whether the median of the sample is higher than 3 (that is, 4 or 5) in the question "How strong or intense was the experience with the helmet compared to daydreaming?" (Scored 1=much weaker, 5=much stronger/more intense). This relates to Hypothesis 3.

The analyses were performed in R 4.2.0 using the BSDA package (Arnholt & Evans, 2021).

Even though this analysis could allow for certain biases like an anchoring effect, we tried to minimize this by asking the questions during the interview and not in a questionnaire. In addition, we gave each answer option a label (e.g., "*2. There may have been some similarities, but I'm not sure"*) to avoid different interpretations of the 1-5 scale. Participants were also encouraged to elaborate on their answers to ensure they interpreted the question correctly. Nevertheless, it is

possible that there were still slightly different interpretations of the questions, introducing some bias.

Results

Descriptives

We recruited 80 participants, but as one participant stopped their participation halfway through the lab session, our final sample consisted of 79 participants, 43 males and 35 females[2]. The age range of the participants was between 18 and 45 years, with 40.5% between 18 and 24 years old and 46.8% between 25 and 34 years old. The participants had a high education on average, with all but one participant having a high school diploma and 57 % having completed their bachelor's degree or a higher degree. The MacArthur Scale of Subjective Social Status showed participants rated their own social status as slightly above average, with a mean score of 61 out of 100 (SD = 17,26). The scores ranged from 20 to 92 and had a close-to-normal distribution.

Furthermore, 65% of participants had prior experience with meditation, 70% had prior experience with psychedelics, and 19% of participants believed in God. Only five participants reported having no previous mystical experiences, and the median[3] number of previous mystical experiences was five.

During the God Helmet session, 67 out of 79 participants reported having some kind of unusual experience. With the counting approach, each participant pressed between 0 and 13 times, with a mean of 4 presses. The presses of 4 participants were not recorded with the gripper due to technical malfunctions and one participant showed 145 presses and had very noisy data, so we excluded this participant from the analysis. The resulting 74 participants used in the threshold approach pressed between 0 and 60 times, with a mean of 14 presses. This large difference in presses can be accounted for by several factors: (1) Participants recalled fewer experiences than they pressed for (2) The counting approach does not count repeated experiences (3) The gripper

[2] One participant preferred not to say their gender.
[3] The median was calculated instead of the mean because participants could only report a maximum of 10 experiences

recorded noise. This last factor seems especially likely to have influenced the data, as some participants had very weak presses that were difficult to distinguish from noise. On the other hand, the graphs of some participants showed clear presses that were not recognized by the participant, which could have been accidental presses or presses caused by unintentional movement. After examining the interviews, I estimate that 20 participants did not recall all their experiences or made erroneous presses and that 17 participants had repeated experiences that were grouped in the counting approach. In addition, nine participants had a lot of noise in their gripper recordings.

The correlation between the counting and threshold approach was moderate (Pearson's r = 0.50), indicating that while they seem to measure the same construct, these two approaches measured the number of experiences during the God Helmet session in different ways.

Our manipulation check in the follow-up one month after the session showed that 62% of participants believed that the God Helmet had stimulated their brain, while 30% believed they had been deceived at some point in the experiment. However, as our manipulation check was measured only after the session, it is likely that more participants began the session believing the helmet would stimulate their brain and, when they did not have any unusual experiences, some inferred they must have been deceived or the helmet was turned off. Indeed, some participants mentioned their response in the follow-up was different to what they had thought during the lab session.

Participants who believed that the God Helmet had stimulated their brain had higher M-scale scores (mean = 86.10) than sceptic participants (mean = 59.00), supporting the earlier findings by van Elk (2015) that whether participants believe in the manipulation has great influence on their experience with the God Helmet. Participants who believed the God Helmet had stimulated their brain also had slightly more button presses according to the threshold (mean = 16.20 vs. 11.20) and the counting approach (mean = 4.58 vs. 3.04), as well as stronger presses (mean = 0.54 vs. 0.28).

Lastly, at least nine participants were recommended to the study by friends or came to the lab in a friend group, violating the assumption of independent sample. However, excluding these nine participants did not alter the results of the quantitative analyses.

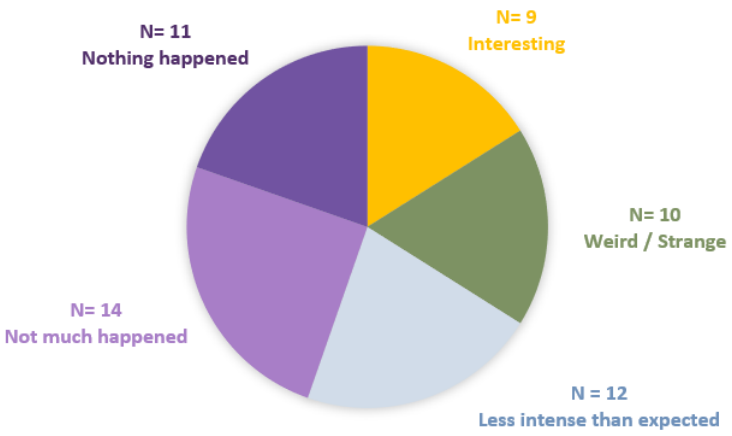
Qualitative analysis

Overall experience

Figure 3 shows the global answers participants gave to the question "How was your experience?". Table 1 below shows some examples for each of these categories. In general, participants who felt that nothing or not much happened did have some sensations and mental imagery but did not find them unusual. Similarly, participants who said the experience was less intense than expected had some interesting experiences to talk about, but they explained these were not as mystical or intense as they had expected at the start of the experiment. Participants who expressed that their experience was weird or strange seemed to have the most intense experiences.

Figure 3

Answers to the Question "How was your experience?"



Note. Only 56 out of 79 participants were used for this chart, as the rest gave too specific answers to group together. Therefore, the proportions of this chart cannot be generalized to the whole sample.

Table 1

Examples of Answers to the Question "How was your experience?"

Nothing happened N = 11	"I feel nothing happened, so I couldn't say anything… Because if... with all these things, if I sit in a room or if I sit for 45 minutes with eyes closed, if I'm not falling asleep, then what happens is the same thing happened to me under the helmet." P31

	"It was okay. But I actually didn't feel anything. So, I did not feel any current, stronger or weaker now, nothing. I did not have any strong mystical experiences" P49 "It was actually- yeah, I was open, right? To receive everything but nothing... happened... maybe I did feel calm [....] calm all the time. Now I do feel a little bit different.... very calm." P21
Not much happened N = 14	"I honestly didn't feel much. I quickly started feeling tingles, kind of shivers, or just being too cold. And then just- I found myself going to some sort of like hypnagogic state. And then I pressed one time because it was like, I finally relaxed the pressure from the helmet, and everything was wearing off, and I didn't feel my- like, the end of the fingers […] anymore. But that was mostly it [...] So again, I pressed. Because I kept feeling the sensations. And I started having... because it was kind of like a hypnagogic state, it was kind of like visions, or almost there but not quite, like your mind, just... But yeah, that was it. Unfortunately didn't feel any, any feelings of unity or the ones we talked about earlier." P64 "I can't say a lot happened. […] it just felt like I was constantly in the space of, like, almost falling asleep but just staying on the edge of that. So kind of like weird little images that are coming in and going out." P5
Less intense than expected N = 12	"Yeah, it was ok. Less intense than I had expected." P77 "The lady before in the video was saying it was quite intense, but I didn't really feel that much." P10 "A bit underwhelming. I was expecting more, I think." P61
Weird/ strange N = 10	"It was interesting. It was kind of strange." P15 "Yeah, it was very, very unlike anything before, I thin. It was, yeah, it was unique." P40 "It was really weird. Really weird […] Really, really weird. Weird stuff." P14
Interesting N = 9	"It was very interesting. And in the sense of mystical feeling, I didn't necessarily have it, but I did go through a bunch of different feelings." P45 "Interesting. Not a whole lot of strong sensations, or experiences, but very solid ones. And there was also- they seem to kind of like sneak in. You're just sitting there. And then suddenly…" P3 "Interesting. Yeah, it was a lot of very random stuff going on that's not comparable to the drug experience or anything" P6 "It was very interesting because... I went everywhere from having deep emotions to lucid dreams. The lucid dreams were really intense." P18

Specific presses

Participants pressed for what they thought was unusual, but it varied from person to person what was considered unusual. For example, some participants pressed for imagery that reminded them of imagery when falling asleep and for tingling sensations, while others did not press for the same experiences as they just attributed them to sitting still for a long time. This could be explained by the level of mental and body awareness in everyday life- some participants may have never paid attention to the mental imagery occurring when falling asleep or have never sat still for an extended period, while others have.

Table 2 shows the categories of experiences that were reported most often. As we can see, most participants reported some kind of bodily sensation (e.g., tingling, warmth, goosebumps), while almost half reported hearing sounds, voices, or music. Some of these auditory experiences were clearly imagined (e.g., hearing music), but it is not clear whether some were actual noises heard despite the white noise (e.g., hearing people talking, footsteps), as the room itself was not very well isolated for sound. Indeed, eleven participants reported wondering whether the sounds they heard were from the outside or were in their heads, which indicates difficulty in attributing agency while wearing the God Helmet.

Interestingly, participants who reported feeling anxious also reported feeling relaxed or warm in the same session. Experiences were often reported as suddenly starting or ending, which added to the unusual feeling of the experiences. Furthermore, the sensation of time was sometimes reported to pass faster or slower within each experience, but in general participants felt the 45 minutes passed very quickly.

Table 2

Experiences Reported Most Often

	Number of participants	**Percentage**	**Example**
Bodily sensation	**69**	**87%**	"I could feel the muscle spasm sort of like tiny, it seemed like tiny muscles are contracting, like, random places, mostly in my legs, and sort of
Tingling	28*		

Feeling a chill/ feeling cold	16*		like tingling sensations that I think spread from the legs to the whole body." P48
Warmth	11*		"I also had this, like, waves of coldness. I just think it's because I was falling asleep. […] So yeah, it was like, wave of cold. Yeah. Nothing, nothing, and then wave of cold. [...] I mean, I have this kind of feeling when I fall asleep, but not so often." "I had a very, not very, but profound serenity felt very nice and warm. I had one feeling all of my body, just felt good. [...] Yeah just a warmness all over the body, almost like... I don't know, on morphine type of feeling. Very womb-like, you know, like, like a hug or something like that." P52
Auditory	**36**	**46%**	"I was very confused […] at a certain point, I realised it was music. But I don't know if it's the music in my head or […] And it was very short, very short, because I realised I kind of heard something. And then when it became more focused, it disappeared." P74
Music	9		
Talking/ voices**	9		
Bird sounds	4		
Visual: Bright / Light	**23**	**29%**	"It was really bright, brighter than you usually see when you close your eyes. And I got this feeling that there was some really bright lights behind me. So it seems like peripheral vision, I have this really bright white light, which sometimes disappeared." P69
Seeing a light	12		
Light flash	10		
Floating sensation	**23**	**29%**	"It was just as if I lost my weight, as in, you know, when you're floating in water, and you just have this sensation of weightlessness? Or like, kind of rising up a little bit to some level and then back down again." P9
Anxious / Afraid	**20**	**25%**	"Like I started to have feel anxiety, and also like a fight or flight type of response because I was picturing a black dog barking. Like, I don't know the race, but yeah, Black Dog barking, which made me very afraid and kind of like wanting to... like I could feel my heartbeat racing. My breathing was different." P47
Heavy / Sinking sensation	17	22%	"I could not- I felt like I could, but I did not want to move it. Because it was too much. But the pelvis was dragged down. So, I was like swallowed." P15

Sensing a presence	9	11%	"Sometimes people were touching my body. In the beginning, I felt someone was like touching my skull. And then, at a certain point, I felt someone pressing my head. And I couldn't move. So, it was really strange." P58
Visual: Space / Stars	9	11%	"…a strange visual effect, like moving to a starfield, but it was very, very subtle, it was not too pronounced. […] Two planes of these lines of small lines. [...] Lines I would say I don't know if you've ever seen Star Wars; it's like they're coming into the hyperdrive." P53 "I was floating through space. It felt like I understood where I was. But at the same time, it's like, you're- since I'm watching from like an outside perspective, I felt like it was moving through like the universe." P27
Body moving / Spinning sensation	4	5%	"The strangest part was like how I felt like I was moving even though I knew I wasn't. Like, at certain parts, I felt like everything around me was just spinning really fast, almost like I was on an amusement park ride or something like this. And at one point, it felt like I would just peel out of my body and just, like, fall forward. So that was kind of an interesting experience, I guess." P15

*Some participants had multiple experiences within one category (e.g., both tingling and warmth). These influence the count of both subcategories (they were added to the N for tingling and the N for warmth).

**It is unclear whether some participants heard people talk outside the experiment room.

Compared to other experiences

Without answering any prompts, 12 participants compared (a part of) their experience to a previous drug experience, 11 compared it to meditation, 21 compared their experience to falling asleep or drifting off, and 15 participants compared it to dreaming. Table 3 shows some examples for each.

Table 3

Comparison of God Helmet Experience to Other Experiences

Drug comparison N = 12	"I had a very, not very, but profound serenity. Felt very nice and warm. I had one feeling, all of my body, just felt good. [...] Yeah, just a warmness all over the body, almost like... I don't know, on morphine type of feeling. Very womb-like, you know, like, like a hug or something like that." P34 "Feeling of contentment. I think it was quite similar to when you take drugs." P78 "One where I felt that... ketamine, you know, the dissociative action between mind and body. Pressed one of those like that, "Oh, wow. It's quite ..." it might have been my body feeding my mind, but I felt them as like separate entities for a part there." P55 "This feeling that chills on my spine, which is what you get [...] when I had the meditation and with MDMA." P18 "It resembled the most to the experience I had with ayahuasca, actually. Resembled to that, in some ways, not as intense, but…" P47
Meditation comparison N = 11	"I was still, like, just meditating. Like, it was kind of- I wasn't planning on meditating. But I was just feeling that state. [...] I was less aware of the world around." P73 "Wasn't that different from like meditation, or like how I would feel while meditating." P68
Falling asleep comparison N = 21	"Like the moment where just before you're starting to dream […] but then you are starting to fall asleep, but then suddenly still wake up again. But you already had like these weird dreamlike images in your head. If that make sense. Yeah, I had a couple of those." P78 "Like a feeling of before you fall asleep, you're almost falling asleep […] It's like, almost as if you're floating, I think? There's no way to put into words. And it's also almost as if you don't really know if you're awake or asleep, or... Yeah, I think for some time you feel like the awareness of whatever is going around, you don't really know, it's like, "Oh, okay, I'm here."" P42 "A couple of times, that falling asleep-like moment which I got pulled back from. I think I didn't press the button on one of those because I wasn't sure if it was significant." P53
Dreaming comparison N = 15	"It was like dreams in a way because like I'm not sure if it was necessarily real, some of it was, but some of it like wasn't. As in... real as in I mean like it comes from like something that I already have lived through, that I experienced. Or some of it was like, completely random" P40

	"… that took me on a little sort of like dreamlike sensation there, where I would hear like like a jungle sound in the white noise […] I felt like I was in a rain forest where I could differentiate between flowing water, chirping birds and insects and wind even though it was just a monotone sound, but in my mind's it felt like a bit like a dream." P62 "And also, there was an element that's really typical of dreams or of lucid dreams. Which is kind of like the unhinged way of connecting thoughts that you have […] just like a really free stream of thoughts that I can normally experience when I... not necessarily when I dream because they feel more real when I dream. But when I smoke, and I don't do anything else, or, or if I'm lucid dreaming, or if I'm like really, really, really tired, and I just lay down." P13 "It felt more like I was dreaming than actually experiencing. Like, a lot of the feelings that I've had, I feel exactly like that in a dream." P39

Compared to previous mystical experiences

When asked whether the experiences with the God Helmet were similar to earlier mystical experiences, participants usually reported there were similar elements such as calmness, bodily sensations, and a sense of "being somewhere else and getting back." However, the experience with the God Helmet was generally less intense than other mystical experiences. When comparing experiences, participants reported they had more physical sensations with the God Helmet, as opposed to more emotional experiences in previous mystical experiences. There was no consensus on whether the type of imagery was similar to previous mystical experiences, with some participants reporting similarities and others noting differences. Participants rated the similarity of their experience with the God Helmet to previous mystical experiences on a scale of 1 (not at all comparable) to 5 (identical), with examples of each rating shown in Table 4.

Table 4

Comparison of God Helmet Experience to Previous Mystical Experiences

Not at all, they were completely different N = 14	"Not much [in common] […] there were... the feelings that I had are very similar to the state between dream and wakefulness. That's exactly what I would compare the feeling to." P34

	"Yeah. Very, very significantly [different] because it was much more chill. And I was in control of everything of my thoughts and what I think about so. So it was just very, very different." P29
There may have been some similarities, but I'm not sure N = 27	"Well, I mean, there was the similarity of, like, being somewhat disconnected from myself, which I feel like happens almost every time I do something out of the ordinary that's like this. I've done sensory deprivation. I kinda had the same thing. Yeah, meditation or psychedelics kind of always get that. Differences? Like almost everything. But I still had like visual stimuli, auditory stimuli." P51
Slightly comparable, there were a few similarities N = 20	"They were not everyday experiences, but I also didn't feel that I was far out, so in a sense, I guess the sensations that I had bodily and mentally was something that were within reach of me on a sober day, probably trying to get there. So, it wasn't that shocking for me. So I can make sense of it. I guess it's not like trips on some psychedelics, and I'm going to need a while to process it. I really enjoy this experience because it's somehow extraordinary. […] I have a bit of ineffability. But it wasn't as strange, as shocking as a trip. And I even feel- I guess I feel more relaxed from all the surroundings... having a trip sitter here with me so it was a very calm and neutral environment for me." P55
Very comparable, the experience reminded me of the other N = 7	"Well, I think fundamentally, they are different from one another, because in the others I was with people... But I do think there's a similarity between this experience and when I was sitting in the chair with the LSD. [...] the focus on the train of thought and like losing every sense of the world around you, and just sitting there like- like sitting there and like, still in your mind. It's something that's very comparable." P43 "I would have images of something, I would feel some emotion, some feeling something like this. And then I will come back and be here, and at some point, I will get back here, which is the same thing I used to have with ayahuasca or the amphetamines, there will be a song, in doing that song, I completely lose control of myself and forget about my body. But then at the end of it -I experienced something, and then at the end of it, come back, and then remind- start breathing again. That was very similar." P47
Identical, I felt like I was reliving a previous experience N = 1	"Oh, like what I had? No similar. Similar. Yeah, completely. […] Like on the feeling that I feel like I'm in an alpha state, and then I'm just- my subconscious is working. That's it." P33

Compared to daydreaming

When asked to compare their expeirence to daydreaming or imagination, participants mostly said that their expeirence with the God Helmet was more fragmented and less coherent than daydreaming. In addition, it was often reported that the experience with the God Helmet was more immersive or more intense than daydreaming. Participants again compaired their experience using a 1-5 scale, and examples for each response can be found in Table 5.

Table 5

Comparison of God Helmet Experience to daydreaming

Not at all, they were completely different N = 12	"When I daydream, I usually really choose the thing that I like to think about and I have a lot of... well, I can steer it very, very well. […] I think when daydreaming I think about more in sentences and more coherent thoughts and less in visuals. And this is this was really visual. [...] Yeah, it's much more visual, and at the same time- and I had less of a grasp on it. I tried to, but I had to really put effort into that. And, and I was always aware, and I was always... sometimes distracted by what was going on around me, which wouldn't happen so much when I was when I'm daydreaming" P69
There may have been some similarities, but I'm not sure N = 9	"Possibly at times? Yeah. Like, not all the time because, I mean, I was trying to, you know, pay attention to my sensations. So like, I was more in this meditative state, I guess, than, you know, daydreaming lost in thought. But yeah, probably there were moments that I kind of drifted away." P68
Slightly comparable, there were a few similarities N = 18	"A little bit because I think I actually had some thoughts [about] where I was going, but then... But then, like the visual experiences, it was clearly not something I was thinking about. Actually- I think I did have a little bit of like, daydreaming or my thought process but it was actually interrupted by the visuals that appeared like the planet or the desert or is there space or the [?]." "There was less of the daydreaming because there were some moments that I just I had some thoughts about, like people or situations come in, but then it was it was interrupted by these experiences." P48
Very comparable, the experience reminded me of the other N = 28	"it's like I know [that] always when I close my eyes, I see... There's like, I don't know how to describe it. There's something I see. But this was like I was seeing more like real things, I guess, like actual figures and faces and things like that. […] More intense, though. And more, more real. But yeah, kind of similar. Yeah." P39
Identical, I felt like I was reliving a previous experience N = 8	"I don't think the daydreaming was enhanced by the Helmet. If you asked me to lay down the chair without the helmet for four or five minutes with lights off, I'll start, you know, the mind will wander way. And that's what the mind does. And I went through the same thing." P67

Unfortunately, the question comparing the God Helmet experiences to daydreaming was not clearly phrased, and as a result, some participants answered the question without elaboration while others made a distinction between the moments when the gripper was pressed and the rest of the experience. A common distinction was that the bodily experiences were very different from daydreaming, while other parts were less so. Due to a lack of clarification in the interviews, it is unclear for some participants whether they answered the question regarding the gripper presses or the rest of the experience.

Quantitative Confirmatory Analyses

Multivariate linear regression

To test Hypothesis 1, I conducted a multivariate linear regression to see whether the number of previous mystical experiences (Previous MEs) predicted the number of unusual experiences with the God Helmet with the counting approach (Counting) and the threshold approach (Threshold), as well as whether it predicted the strength of these experiences (Strength), and the score on the Mysticism scale (M-scale score).

The descriptive statistics for these variables can be found in Table 4. For the variable Strength, only participants that reported pressing the gripper were included, resulting in a lower sample size. In addition, the gripper data for some participants was saved incorrectly, adding to the lower sample size for Strength and Threshold. For the M-scale score, we miss one participant who had to leave the lab unexpectedly before filling in the scale at the end of the session.

The assumptions for linear regression were not completely met, as the independent variable Previous MEs is not continuous, but a count variable. Nevertheless, I still chose to perform a regression, as this is the analysis most intuitive to interpret. For this analysis I used a Bonferroni correction for the four dependent variables, making $\alpha = 0.0125$. Table 4 and 5 show the descriptive statistics of the variables used in this analysis, and Table 6 shows the results.

Table 4

Descriptive Statistics for the Four Dependent Variables (Counting, Threshold, Strength, M-Scale Score) and the Predictor (Previous MEs)

	N	Mean	SD	Median	Min	Max	Skew
Counting Self-reported number of unusual experiences	79	3.99	2.84	4.00	0.00	13.00	0.57
Threshold Number of gripper presses indicating unusual experiences	74	13.77	12.40	11.00	0.00	60.00	1.42
Strength Strength of strongest gripper press	63	2.80	2.19	2.40	0.21	9.21	1.21
M-Scale Score Indicating mystical experiences	78	76.92	27.68	72.50	34.00	156.00	0.61
Previous MEs Number of previous mystical experiences	79	4.97	3.02	5.00	0.00	10.00	0.19

Table 5

Pearson's r Correlation Table for the Four Dependent Variables (Counting, Threshold, Strength, M-Scale Score) and the Predictor (Previous MEs)

	Counting	Threshold	Strength	M-scale score	Previous MEs
Counting	1.00	0.50***	0.28*	0.48***	0.54***
Threshold	0.50***	1.00	0.52***	0.42***	0.31**
Strength	0.28*	0.52***	1.00	0.32*	0.32*
M-Scale Score	0.48***	0.42***	0.32*	1.00	0.30**
Previous MEs	0.54***	0.31**	0.32*	0.30**	1.00

Note. Pairwise deletion was used to calculate these correlations. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Table 6

Results of the Multivariate Linear Regression. This analysis tests whether the number of previous mystical experiences (Previous ME) predicts self-reported number of unusual experiences with the God Helmet (Counting), number of unusual experiences indicated with gripper presses (Threshold), strength of the strongest gripper press during the God Helmet session (Strength), and score on the Mysticism Scale (M-Scale Score).

	Effect	Estimate	*SE*	t-value	*p*	95% CI		R^2
						LL	UL	
Counting (Regression 1)	Intercept	1.465	0.525	2.789	0.007*			
	Previous ME	0.507	0.090	5.609	<0.001**	0.327	0.687	0.290
Threshold (Regression 2)	Intercept	7.348	2.668	2.754	0.007*			
	Previous ME	1.298	0.462	2.810	0.006*	0.377	2.219	0.099
Strength (Regression 3)	Intercept	1.624	0.563	2.884	0.005**			
	Previous ME	0.216	0.009	2.363	0.021	0.033	0.398	0.084
M-Scale Score (Regression 4)	Intercept	63.189	5.858	10.787	<0.001**			
	Previous ME	2.740	1.003	2.733	0.008*	0.743	4.737	0.089

Note. Pairwise deletion was used for this analysis. As a Bonferroni correction was used, significance is as follows: *$p < 0.0125$. **$p < 0.001$.

Regression 1 was significant ($F(1,77) = 31.46$, $p < 0.001$), and previous mystical experiences explained 29% of the variation in the number of unusual experiences that participants had using the counting approach ($R^2 = 0.29$). Participants who had more previous mystical experiences had more experiences with the God Helmet according to the counting approach ($b = 0.507$).

Regression 2 was also significant ($F(1, 72) = 7.898$, $p = 0.006$), where previous mystical experiences explained 9.9% of the variation in the number of unusual experiences according to the threshold approach ($R^2 = 0.099$). Participants who had one more previous mystical experience had on average one more experience with the God Helmet ($b = 1.298$) according to the threshold approach.

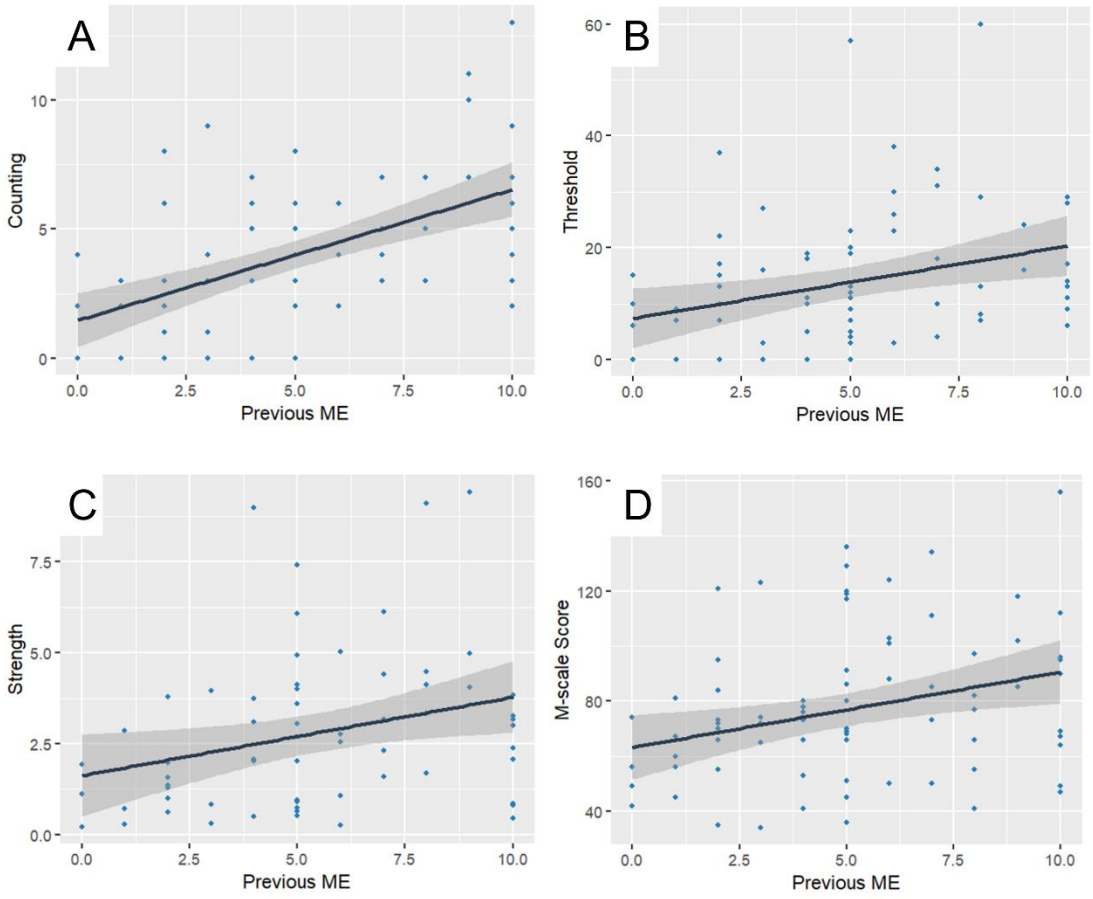
Regression 3 was not significant due to the Bonferroni correction ($F(1,61) = 5.59$, $p = 0.021$, $R^2 = 0.08$). Participants with one more previous mystical experience gripped on average 0.216 points stronger during their strongest unusual experience with the God Helmet.

Regression 4 was significant ($F(1,76) = 7.469$, $p = 0.008$, $R^2 = 0.09$). Participants who had one more previous mystical experience had on average 2.740 more points in their M-scale score.

When examining the data, the Counting and Threshold variables had Poisson-like distributions, which violated the normality assumption. This was confirmed by a significant Shapiro-Wilk test, which also found the Strength and M-scale score variables to be non-normally distributed. To address this issue, I applied a square root transformation to all dependent variables, which resolved all normality issues. I chose this transformation since it is appropriate for Poisson distributions and helpful due to the numerous 0 values in the data (Alexopoulos, 2010). Additionally, it resulted in more normal-looking data compared to a log transformation with an added constant of 1 (i.e., a log(x+1) transformation). After the transformation, all regression analyses remained significant, indicating the results are robust. In addition, Regression 3 became significant with the Bonferroni correction after transformation ($F(1,61) = 6.95$, $p = 0.011$, $R^2 = 0.08$). However, the analysis after transformation should be viewed as exploratory, and no inference should be made from this significant result.

Figure 4

Scatterplots and Regression Lines for the Predictor Number of Previous Mystical Experiences (Previous ME) Plotted Against the Four Dependent Variables: (A) Self-reported number of unusual experiences with the God Helmet, (B) number of unusual experiences indicated with gripper presses, (C) strength of the strongest gripper press during the God Helmet session, and (D) score on the M-scale.



Note. Regression lines are shown with 95% CI lines in grey.

Permutation analysis

To test Hypothesis 2, namely whether the experience with the God Helmet was similar to previous mystical experiences, I conducted a permutation analysis that would allow me to see whether the average ranking of the God Helmet experience was close to first position (i.e., stronger than previous mystical experiences), somewhere in the middle (i.e., similar to previous mystical experiences), or close to last position (i.e., weaker than previous mystical experiences).

Seventy-four participants had previous mystical experiences and filled in the ranking. Out of these, 6 participants ranked the helmet in first place, 30 ranked the helmet in between other experiences, and 38 participants ranked the helmet lowest in terms of intensity of the experience compared to previous mystical experiences. After normalization (i.e., dividing the rank of the God Helmet by the amount of previous mystical experiences), the mean rank of the God Helmet was 0.79, indicating that the God Helmet experience was on average less intense that other mystical experiences. As an example, if the God Helmet is ranked in position 5/5, after normalization it would get a rank score of 1, while a rank of 1/10 would get a rank score of 0.1.

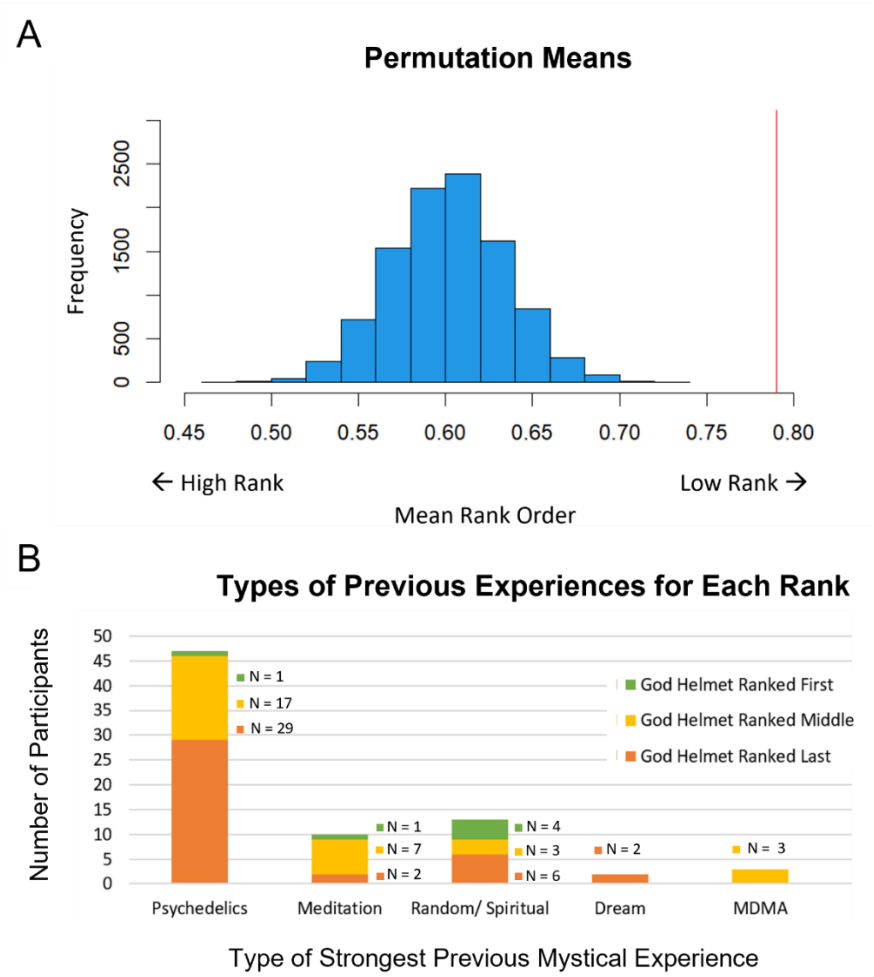
The permutation analysis was significant ($p < 0.001$). As the mean rank of the God Helmet experience is closer to 1 than to 0, the high significance means that the God Helmet experience was ranked significantly lower than other mystical experiences. The God Helmet experience is therefore on average less intense than other mystical experiences, and thus different from other mystical experiences. See Figure 5A for an illustration of the permutation results.

To assess the impact of the inclusion of participants with 1-2 prior mystical experiences, I conducted an exploratory analysis with only participants who had 3 or more previous mystical experiences. Effectively, these 58 participants turned out to have 4 or more previous mystical experiences. The mean rank of the God Helmet for this sample was 0.76, and again in the tail of the distribution. Therefore, the results of the permutation analysis seem robust.

Figure 5B shows what types of experiences participants reported as their strongest mystical experience prior to wearing the God Helmet, divided according to how they ranked the God Helmet experience. As we can see, most of our participants' strongest previous mystical experiences were induced by psychedelics. However, it seems that the higher the God Helmet experience was ranked, the fewer participants had had a psychedelic experience of mystical nature to compare it with. A reason for this pattern could be that psychedelic experiences are stronger than experiences induced in other ways. Indeed, participants who reported difficulty deciding whether their previous experiences had been mystical had not had experiences induced by psychedelics.

Figure 5

Results from Permutation Analysis. Panel (A) shows the mean rank of the God Helmet (showing how intense the God Helmet experience was compared to previous mystical experiences) marked as a vertical red line. As we see, it is on the end of the distribution that indicates a low rank, indicating that the God Helmet is found to be less intense than other mystical experiences. (B) Shows what type of previous mystical experiences participants compared the God Helmet with, i.e., the category to which each highest-ranking previous mystical experience belongs to.



Note. When looking at the data of the one participant who had a strong psychedelic experience and ranked the God Helmet in first place, it appeared that the ranking had been recoded erroneously, as this participant had had no unusual experiences with the God Helmet.

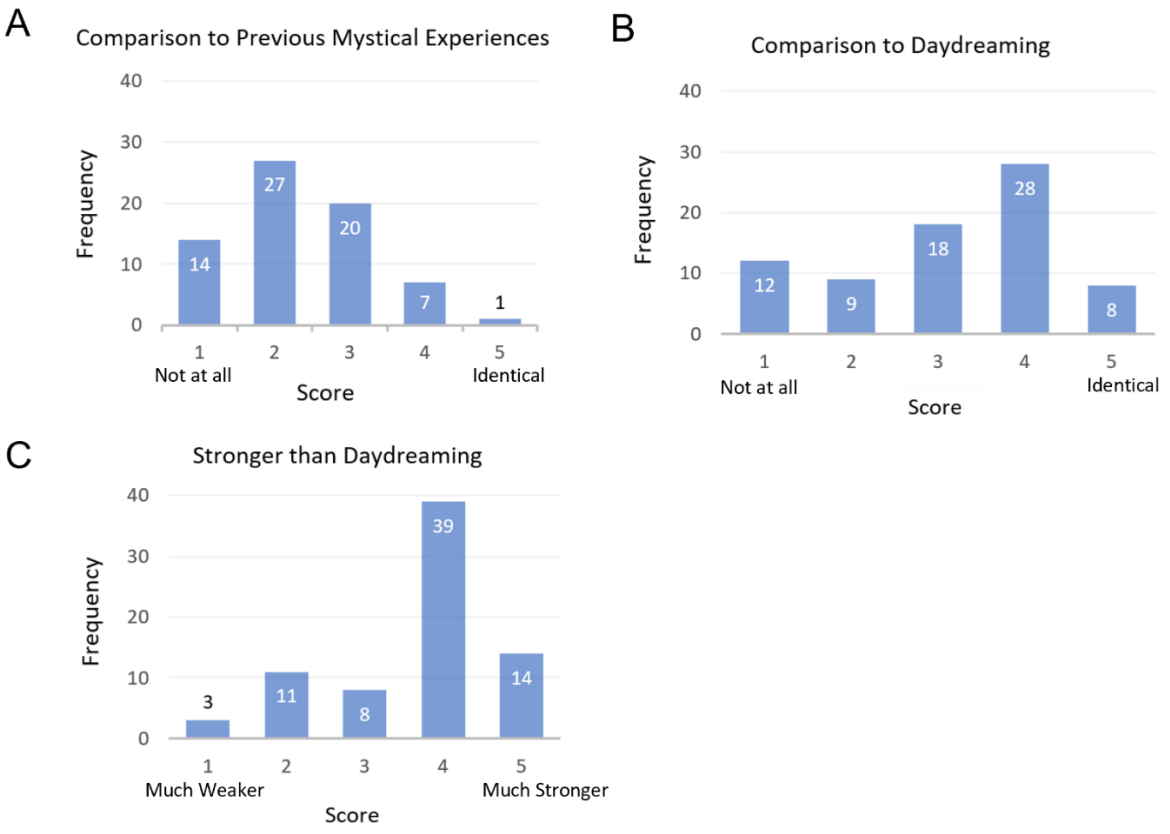
One-sample median tests

To see whether participants judged their experience with God Helmet as comparable to daydreaming or imagination and comparable to their previous mystical experiences, we looked at the ratings for the questions (1) *"How much do you think the experiences are comparable?"* (2) *"Think of yourself daydreaming, for example when you get lost in thoughts or you are lost in imagination. Were the experiences with the helmet similar to that?"* and (3) *"How strong or intense was the experience with the helmet compared to daydreaming?".* All 79 participants answered these questions. Figure 6 below shows the response score of the three questions asked.

In general, participants who reported the experience with the God Helmet as similar to daydreaming still reported it being stronger or more intense than daydreaming. Participants explained the sensory deprivation and lack of distractions amplified their daydreaming. On the other hand, participants who reported their experience to be different from daydreaming usually referred to the bodily sensations, visuals, or emotions being much stronger than what they usually experience while daydreaming.

Figure 6

Answer Distribution of Comparison Questions. Frequency of responses for the questions: (A) "How much do you think the experiences are comparable?", scored from 1 (not at all) to 5 (identical); (B) "Think of yourself daydreaming, for example when you get lost in thoughts or you are lost in imagination. Were the experiences with the helmet similar to that?", scored from 1 (not at all) to 5 (identical); and (C) "How strong or intense was the experience with the helmet compared to daydreaming?", scored from 1 (much weaker) to 5 (much stronger).



To test whether participants judge the experience with the God Helmet to be different from previous mystical experiences (Hypothesis 2) and from daydreaming and imagination (Hypothesis 3), I performed an exact one-sample median test on each question. Ties were not removed in questions 1 and 2 due to the 1-5 scale lacking a neutral answer option. In addition, the restricted 1-5 answering scale would have resulted in a high number of ties. Ties were removed in question 3, where "The same as daydreaming" was a neutral answer.

The one-sample median test on the rating for similarity of previous mystical experiences with the God Helmet (Hypothesis 2) was non-significant, with a median estimate of 2 (p = 1.00, 95% CI [2,5]), so the null hypothesis that the experience with the God Helmet is not comparable to previous mystical experiences cannot be rejected. This indicates that it is estimated that the population will give a rating of 2 (i.e., "There might have been some similarities with previous mystical experiences, but I'm not sure"). The probability of success was 0.12 (95% CI [0.06, 1.00]), which means that the estimated probability that the population would rate the experience with the

God Helmet very comparable or identical to previous mystical experiences is 0.12 (i.e., there is 12% chance that people will give this rating). This probability results in a Cohen's g effect size of 0.38.

The one-sample median test on the rating for similarity of daydreaming or imagination with the God Helmet (Hypothesis 3) was not significant, with a median estimate of 3 ($p = 0.41$, 95% CI [1,4]), so the null hypothesis that the experience with the God Helmet is similar to daydreaming or imagination cannot be rejected. The probability of success was 0.52 (95% CI [0.42, 1.00]), resulting in a Cohen's g effect size of 0.02. Therefore, the chance of the God Helmet experience being rated similar to daydreaming is nearly equal to it being rated dissimilar.

The one-sample median test on whether the God Helmet experience was stronger than daydreaming or imagination (Hypothesis 3) was tested by looking at whether the rating was higher than 3. This indeed was the case, the test was significant ($p < 0.001$) with a median estimate of 4 (95% CI [4,5]). This indicates that it is estimated that the population will give a rating of 4 (i.e., the God Helmet is a bit stronger/more intense than daydreaming). The probability of success was 0.79 (95% CI [0.69, 1.00]), resulting in a Cohen's g effect size of 0.29. The estimated probability that the population would rate the experience with the God Helmet as a bit stronger than daydreaming or much stronger than daydreaming is therefore 0.76 (i.e., there is a 76% chance that people will give this rating) and the null hypothesis that the experience with the God Helmet is as strong as daydreaming or imagination is rejected.

Quantitative Exploratory analyses

Social Desirability

As we also measured social desirability in our questionnaire battery during participant screening, I did an exploratory analysis to see whether my results could be explained by differences in social desirability, i.e., participants adapting their responses to fulfil the researcher's expectations. Social desirability was measured with the 10-item version of the Marlowe-Crowne Social Desirability Scale developed by Strahan & Gerbasi (1972), which has been found to be a significant improvement

over other social desirability scales (Fischer & Fick, 1993), including the original 33-item form (Crowne & Marlowe, 1960).

In our study, the social desirability scale had a Cronbach's alpha of 0.58, indicating the internal consistency of this scale was poor. Nevertheless, I added the social desirability scale as a covariate in the multivariate regression, and it did not affect the results. In addition, social desirability did not correlate significantly with any of the acute measures (i.e., Reported number of unusual experiences with the God Helmet right after the session, Pearson's r = -0.04; Number of unusual experiences indicated with gripper presses, Pearson's r = -0.07; Strength of the strongest gripper press during the God Helmet session, Pearson's r = 0.02; M-scale score, Pearson's r = 0.01). Furthermore, social desirability did not correlate with the ranking position of the God helmet (Pearson's r = 0.15, p = 0.20), indicating that the ranking was not influenced by social desirability.

Long-term Effects

To evaluate potential long-term effects of the God Helmet, we asked participants to fill in the Flourishing Scale at home during baseline (2 weeks before the helmet session) and one day, one week, and one month after the helmet session. This 8-item Flourishing Scale, developed by Diener et al. (2010), assesses well-being and ranges in score from 8 to 56. Descriptive statistics for each time point are presented in Table 7, showing little difference in mean score between the time points. I found a similar small difference when excluding participants with missing data listwise (N = 46), with a mean baseline score of 42.63 trending upward until a score of 44.16 at the one-month follow-up. Unfortunately, participant response times to the follow-up questionnaires varied significantly, compromising the accuracy of the data. I therefore chose to only analyse the last timepoint, one month after the helmet session, compared to the baseline.

For further inspection, a correlation table of the Flourishing variables and the other acute measures during the God Helmet session is shown in Table 8. Here we see that neither the Flourishing score after one month nor the same score after subtracting Baseline Flourishing scores are correlated with the reported number of unusual experiences with the God Helmet (Counting),

the number of unusual experiences indicated with gripper presses (Threshold), the strength of the strongest gripper press during the God Helmet session (Strength), or M-scale score.

To see whether participants who scored highly on the Mysticism scale (M-scale) during the session had higher scores in the Flourishing One Month follow-up questionnaire when correcting for the Baseline Flourishing questionnaire, I performed an exploratory multiple linear regression.

Table 7

Descriptive Statistics of the Flourishing Scale at Baseline and One Day, One Week, and One Month After the God Helmet Session.

	N	Mean	*SD*	Median	Min	Max	Range	Skew	*SE*
Baseline	79	43.08	6.86	44	24	56	32	-0.67	0.77
Follow-up One Day	54	43.72	6.23	45.5	28	53	25	-0.87	0.85
Follow-up One Week	62	44.00	7.13	45.5	22	56	34	-1.01	0.91
Follow-up One Month	74	44.95	7.33	46.5	16	56	40	-1.47	0.85

Note. The follow-up measures were sometimes filled in later than the desired days.

Table 8

Pearson's r Correlation Table for the Dependent Variables Measured During the God Helmet Session (Reported Number of Unusual Experiences with the God Helmet, i.e. Counting; Number of Unusual Experiences Indicated with Gripper Presses, i.e. Threshold; Strength of the Strongest Gripper Press During the God Helmet Session, and M-Scale Score) And the Variables Flourishing Score at Baseline, Flourishing Score After One Month, and the Difference Between These Two Flourishing Scores.

	Counting	Threshold	Strength	M-Scale Score	Flourishing Baseline	Flourishing Score One Month	Flourishing Difference Score
Counting	1.00	0.62***	0.29*	0.47***	0.03	0.09	0.13
Threshold	0.62***	1.00	0.33*	0.45***	0.03	0.11	0.16
Strength	0.29*	0.33*	1.00	0.36**	-0.18	-0.08	0.12
M-Scale Score	0.47***	0.46***	0.36**	1.00	-0.04	0.06	0.16
Flourishing Baseline	0.03	0.03	-0.18	-0.04	1.00	0.70***	-0.27*
Flourishing Score One Month	0.09	0.11	-0.08	0.06	0.70***	1.00	0.49***
Flourishing Difference Score	0.13	0.16	0.12	0.16	-0.27*	0.49***	1.00

Note. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Seventy-four participants filled in the last follow-up questionnaire. At baseline, these 74 participants had a mean Flourishing score of 43.46 (SD = 6.72) ranging from 24 to 56. After one month, the mean was 44.93 (SD = 7.43) ranging from 16 to 56. The regression testing whether the M-scale score predicted Flourishing score after one month, correcting for baseline, was significant ($F(3,68) = 27.47$, $p < 0.001$, $R^2 = 0.55$). The coefficient estimates of M-scale score, Flourishing One Month follow-up, and the interaction between the two were all significant (See Table 9).

The significant M-scale score regression coefficient shows that, when correcting for Flourishing score at baseline, participants with higher M-scale scores during the God Helmet session had higher Flourishing scores at the one-month follow-up. Despite this relationship between M-scale score and Flourishing after one month being weak, as indicated by a small partial correlation of 0.10 and a modest regression coefficient of 0.32, the relationship observed is unlikely to have occurred by chance. However, the small effect size implies that the M-scale score accounts for a relatively small portion of the variation in the Flourishing score after one month, when Flourishing Baseline is held constant.

The negative coefficient for the interaction term ($b = -0.007$) suggests that the effect of M-scale score on Flourishing score after one month decreases as the level of Flourishing Baseline score increases. This is also reflected in Figure 7, where we see that participants who initially had a low Flourishing score, but had a mystical experience, scored much higher in the Flourishing questionnaire one month later. However, participants who already had a high Flourishing score at baseline do not show much improvement after one month, even if they had a mystical experience. This suggests a ceiling effect, likely due to the upper limit of the Flourishing scale being already reached at baseline.

Table 9

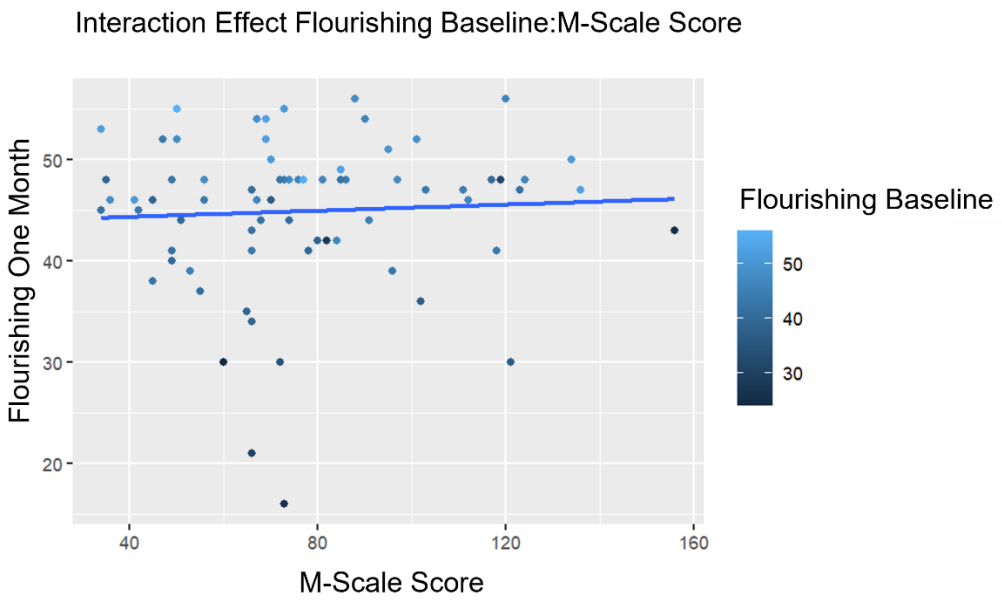
Results of the Multiple Linear Regression. This analysis tests whether the Mysticism Scale scores right after wearing the God Helmet predict Flourishing scores one-month after the session (Flourishing One Month), while controlling for baseline Flourishing scores two weeks before the session.

Predictor	Estimate	*SE*	t-value	*p*
Intercept	-15.767	10.835	-1.455	0.150
Flourishing Baseline	1.355	0.248	5.464	<0.001
M-Scale Score	0.319	0.120	2.653	0.010
Flourishing Baseline:M-Scale Score	-0.007	0.003	-2.460	0.016

Note. As this is an exploratory analysis, p-values are not confirmatory.

Figure 7

Scatterplot Showing the Interaction Effect of Baseline Flourishing Score and M-Scale Score on Flourishing Score After One Month.



Discussion

In this study, I investigated whether suggestion and placebo effects can induce mystical experiences using a placebo brain stimulation device, the God Helmet. While wearing the God Helmet, 67 out of 79 participants reported at least one unusual experience. The most reported unusual sensations were bodily, such as tingling, warmth, and goosebumps, followed by auditory sensations, visuals of a bright light, and floating sensations. Although these experiences were often described to be similar to mystical experiences in terms of feelings of calmness, tingling and other bodily sensations, and a sense of being transported to another place and returning, participants did not find the experience with the God Helmet comparable to their previous mystical experiences. Indeed, participants generally did not report strong instances of unity, sacredness, paradoxicality, or other dimensions of mystical experience as defined by Stace (1960). In addition, participants rated the God Helmet experience as less intense compared to their previous mystical experiences, as indicated by a permutation analysis. Even with this distinction between the experiences with the God Helmet and other mystical experiences, an exploratory linear regression indicated that participants who did have a mystical experience with the God Helmet, measured with the Mysticism Scale, also had positive long-term effects as measured with the Flourishing Scale. This indicates that, even though our efforts to maximize suggestibility and create an optimal context for detecting the effects of the God Helmet did not cause mystical experiences in most participants, some participants did score highly on the Mysticism Scale and had long-term positive wellbeing changes. Therefore, placebo-induced mystical experiences seem to be similar to psychedelic-induced mystical experiences in their long-term effects but are difficult to induce with the God Helmet.

The comparison of the God Helmet experience with daydreaming or imagination yielded mixed results, with participants reporting similarities to daydreaming as often as they reported differences. However, the phrasing of the question may have contributed to this ambiguity, as some participants compared only the most intense moments with the God Helmet to daydreaming while others compared the entire experience. Despite this ambiguity, participants clearly reported that the

experience with the God Helmet was stronger than daydreaming. Therefore, the God Helmet appears to induce unusual experiences, even if these are different from mystical experiences induced by psychedelics, meditation, and spiritual contexts.

Furthermore, I found that previous mystical experiences impact the experiences induced by the God Helmet: Participants with more previous mystical experiences reported more unusual experiences with the God Helmet and had a higher M-scale score. An exploratory analysis indicated these results were not influenced by social desirability, which did not correlate with any of the measures. However, Cronbach's alpha showed that the social desirability scale was not very reliable.

One possible explanation is that individuals with more previous mystical experiences are more susceptible to entering these states. Studies have found that participants who score high on the personality trait absorption (Maij & van Elk, 2018), spiritual participants (Maij, van Elk, & Schjoedt, 2019), and those with prior paranormal experiences (Andersen et al., 2014) have a higher likelihood of experiencing unusual experiences with the God Helmet. The reason for the higher rate of unusual experiences in some individuals may be due to their imprecise coding of self-generated sensory information. Specifically, the brain sends predictive signals of all self-generated action, but when these signals are coded in an imprecise way, it can result in a failure to anticipate the sensory effects and lead to hallucinations or false perceptions (van Elk & Alemán, 2017). This is consistent with research on schizophrenic individuals, who are prone to hallucinations and have reduced activity in the sensory cortex, which is paired with imprecise coding of sensory information (Fletcher & Frith, 2009). Therefore, inaccurate coding of self-generated sensory information may make some individuals, such as those with high absorption, more likely to experience unusual states induced by the God Helmet. Alternatively, some individuals may simply have a lower decision threshold for when they consider their experience "mystical", also called liberal acceptance bias (Prike et al., 2018). They might ascribe mystical qualities to even mild experiences, while others adopt a more conservative response strategy.

Interestingly, 45% of our participants compared their experience to falling asleep and dreaming without any prompts. This indicates that the God Helmet may induce a hypnagogic state, a state that people experience while falling asleep. This state can also occur during daytime when engaged in a passive activity and differs from daydreaming due to its perceived lack of self-direction (Gurstelle & de Oliveira, 2004). Similar to the reported experiences with the God Helmet in this study, hypnagogic imagery is characterized by bizarre and intrusive images, auditory sensations like music and speech, and physical sensations like falling (Goupil & Bekinschtein, 2012). Previous studies have already pointed out the similarities between hypnagogic imagery and the experiences with the God Helmet (Simmonds-Moore et al., 2019) and with similar sensory deprivation contexts like the floating tank (Kjellgren, 2003), supporting the idea that the God Helmet can induce hypnagogic states.

In conclusion, while the experiences induced by the God Helmet may share some similarities with mystical experiences, they are different in important ways, such as the predominance of physical sensations rather than emotional ones, the absent sense of 'needing time to process the experience', and the absence of long-term positive effects. However, the experiences induced by the God Helmet are not ordinary, indicated by their reported intensity compared to normal daydreaming. In addition, almost half of the participants in this study compared their experience with the God Helmet to falling asleep or dreaming, indicating similarities with hypnagogic states. Although the extent of these similarities still needs to be determined, these findings suggest that the God Helmet may be a useful tool for inducing hypnagogic states in a short time frame. Similarly to meditation and relaxation techniques like Yoga Nidra that help induce hypnagogic states, the God Helmet or a variation of it could be used in sleep research to induce hypnagogic states more reliably than waiting for participants to fall asleep.

Additionally, I found that participants with more previous mystical experiences were more likely to have unusual experiences in this suggestive and sensory deprived context. These findings highlight the importance of considering individual differences and past experiences when

investigating altered states of consciousness, particularly in the context of emerging research on the therapeutic potential of altered states induced by psychedelics and other techniques. By identifying individuals who are more likely to experience these states, clinicians and researchers may be better able to target interventions and maximize their efficacy.

Overall, this study highlights the distinct nature of the experiences induced by the God Helmet and its effects on consciousness and perception, underscoring the need for further research to explore the complex interactions between individual differences, context, and altered states of consciousness.

Limitations

In this study, we showed participants a video explaining mystical experiences and then asked them to judge whether they had had any previous mystical experiences. As we relied on self-report for this measure, it is possible that not all the reported previous experiences were truly mystical. Furthermore, participants were asked to recall their most intense previous mystical experiences, which may have occurred from weeks to years before the session, introducing possible recall bias.

Furthermore, our method of recording the number of unusual experiences with a gripper response was suboptimal. Some participants mentioned that pressing the gripper got them out of a sensation, while others explained it was difficult to know when an experience ended to press the gripper afterward. In addition, when we showed participants their graph of presses, they usually reported less experiences than what the graph showed, which could be due to noise in the recording or erroneous recall. On a positive note, however, the presses correlated with self-report showing some evidence of convergence and validity, suggesting potential for indicating unusual experiences with a press. In future studies, we advise a method where participants can say a keyword out loud to improve recall of experiences and be able to discard noisy presses, and perhaps use a button press instead of a handheld gripper to reduce the amount of noise recorded. Nevertheless, as unusual experiences seem to flow into one another, it will remain a difficult variable to measure.

Generalizability of results

The conclusions of this study are only valid for the sample at hand, as participants were not randomly drawn from the population. Most participants heard of this study via our targeted Facebook and Instagram advertisement, which likely introduced self-selection bias. In addition, the assumption of independent observations was not met, as some participants (at least nine participants that we know of) were recommended to the study by their friends or came to the lab in a friend group. Therefore, our results cannot be generalized to the broader population, and it is best not to rely on statistical inference from the results of this study.

Although the generalizability of our findings is limited, we can still conclude that for this sample, consisting mostly of participants with previous mystical experiences interested in participating in such a study, the experiences with the God Helmet were not identical to other mystical experiences.

Concluding remarks

In an earlier study conducted by Andersen et al. (2014), the God Helmet was used as a tool to induce mystical experiences for the purpose of studying them in a laboratory setting. The researchers concluded that their experimental design was effective in inducing mystical experiences. However, the current study questions if the experiences caused by the God Helmet are truly mystical. This raises concerns about the validity of using placebo God-Helmet manipulations as a means of studying mystical experiences. Instead, more powerful induction techniques, such as the use of psychedelics, may be necessary to induce true mystical experiences accurately and reliably in a lab setting. Finally, it is crucial to be cautious when using the term "mystical experiences," as not all experiences labelled as such may qualify as genuine mystical experiences. Embraced by the veil of mystery, these experiences continue to intrigue, defying easy categorization and remaining as enigmatic as they are profound; their elusive nature only serves to further entice scientific curiosity.

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Appendix A

Power analyses

To determine the number of participants needed for this study, we conducted power analyses using G*Power (Faul et al., 2007). For the one-sample median test, G*Power indicated that a sample size of N= 69 would be needed for a medium effect size (0.15) and 0.80 power. For the multivariate linear regression, a sample size of N = 78 would be needed for a medium effect size (f^2 = 0.15), α = 0.0125 (Bonferroni correction for 4 dependent variables) and 0.80 power. Therefore, a minimal sample size of N = 78 would be needed for both analyses.

We also conducted several sensitivity analyses to see which effect sizes we would be able to measure with 80 participants. A one-tailed correlation analysis with 80 participants, an alpha level of 0.05, and a power of 0.90 would enable the detection of an effect size of at least 0.32. A power of 0.80 would afford the detection of an effect size of at least 0.27. A one-sample median test with N = 80, α = 0.05 and power of 0.80 would afford the detection of an effect size of at least 0.14. Lastly, a multivariate linear regression with N = 80, alpha = 0.0125 and power of 0.8 would afford the detection of an effect size of at least 0.15.

Based on these power and sensitivity analyses and feasibility constraints, mainly concerning the long session time per participant and the university credits allocated to this project, we decided to test 80 participants.

Appendix B

Measures for the full study

Questionnaires used

Hood's Mysticism Scale

We used the 32-item Mysticism Scale (Hood, 1975) to measure the extent to which a participant had a mystical experience with the God Helmet.

Modified Tellegen Absorption Scale

We used the 34-item modified Tellegen Absorption Scale (Jamieson, 2005) to measure the trait absorption, which is an adapted version of the Absorption Scale (Tellegen & Atkinson, 1974).

Questions from Griffiths et al. (2006)

We used three questions from Griffiths et al. (2006) to assess changes in meaningfulness, spiritual significance and subjective well-being after the experience at the lab.

1. How personally meaningful was the experience?

   1= no more than routine, everyday experiences

   2= similar to meaningful experiences that occur on average once or more a week

   3= similar to meaningful experiences that occur on average once a month

   4= similar to meaningful experiences that occur on average once a year

   5= similar to meaningful experiences that occur on average once every 5 years

   6= among the 10 most meaningful experi- ences of my life

   7= among the 5 most meaningful experiences of my life

   8= the single most meaningful experience of my life

2. Indicate the degree to which the experience was spiritually significant to you

   1= not at all

   2= slightly

   3= moderately

   4= very much

5= among the 5 most spiritually significant experiences of my life

6= the single most spiritually significant experience of my life

3. Do you believe that the experience and your contemplation of that experience have led to change in your current sense of personal well- being or life satisfaction?

+3= increased very much

+2= increased moderately

+1= increased slightly

0= no change

−1= decreased slightly

−2= decreased moderately

−3= decreased very much

Flourishing Scale

We used the 8-item Flourishing Scale (Diener et al., 2010) to measure changes in self-perceived success in important areas of human functioning, which reflect overall well-being. The items from the Flourishing scale are rated from 1 (strongly disagree) to 7 (strongly agree).

1. "I lead a purposeful and meaningful life"
2. "My social relationships are supportive and rewarding"
3. "I am engaged and interested in my daily activities"
4. "I actively contribute to the happiness and well-being of others"
5. "I am competent and capable in the activities that are important to me"
6. "I am a good person and live a good life"
7. "I am optimistic about my future"
8. "People respect me"

Supernatural beliefs

Participants indicated their agreement from 1 (strongly disagree) to 5 (strongly agree) with the following nine statements, which were selected by Lindeman et al. (2019) to represent supernatural beliefs including both religious and other supernatural beliefs:

1. "I believe in God"
2. "I believe in life after death"
3. "The universe originated from intelligent design"
4. "The universe has an ultimate purpose"
5. "I believe in fate"
6. "There is spiritual energy in the universe"
7. "In the universe, everything is connected in a way that cannot be explained scientifically"
8. "Telepathic mind reading is possible"
9. "I believe in angels."

Marlowe-Crowne Social Desirability Scale

We used a 10-item version of the Marlowe-Crowne Social Desirability Scale, which measures whether participants are likely to adapt their responses to fulfill the researcher's expectations. This scale was developed by Strahan and Gerbasi (1972) and has been found to be a significant improvement over other social desirability scales (Fischer & Fick, 1993), including the original 33-item form (Crowne & Marlowe, 1960).

Multidimensional Assessment of Interoceptive Awareness (MAIA)

We used the Multidimensional Assessment of Interoceptive Awareness scale (Mehling, et al. 2012) to measure the extent to which people are aware of their bodily sensations. This questionnaire has 32 items and a proposed factor structure of 8 dimensions.

Altered Self-Consciousness Questionnaire

To assess to what extent the experience that people have involve changes in the sense of self we used the theoretical framework of Milliere et al. (2018) and Taves (2020) to construct a short questionnaire. The two main dimensions suggested by Milliere et al. (2018) are

narrative self-loss and multi-sensory self-loss. The scale will include approximately 30 items based on drafted versions by the authors.

Self-Assessment Manikin

A computer version of this picture -oriented, brief and nonverbal measure of emotional state (Bradley & Lang, 1994) was used to obtain subjective ratings of valence, arousal and control during emotional events preceding button presses.

Custom questions and order of presentation

Screening

1. "*Does any of the following apply to you?"*

- *I have epilepsy*
- *I faint easily*
- *I have claustrophobia*
- *I have a form of brain damage (as result of a stroke, infarction, serious injury to the head or neurosurgery)*
- *I am taking medication that might affect emotional functioning (e.g., antidepressants)*
- *I have Botox injections in the face*

2. *"Do you have prior experience with meditation? If yes, for how many years? How regular was your practice?"*

- *Indicate frequency within one week*
- *Indicate average duration of a meditation session*
- *Indicate type of meditation*

3.*"Do you have prior experience with psychedelics? If yes, how many experiences have you had? What type of psychedelics did you use? On average, how frequently do you take psychedelics?"*

4. Rate agreement to supernatural beliefs items (see Appendix 1.4)

5. Fill in Modified Tellegen Absorption Scale

6. Fill in the Marlowe-Crowne Social Desirability Scale

7. Fill in the Flourishing Scale

8. Fill in the Multidimensional Assessment of Interoceptive Awareness Scale

Semi-structured interview

1. Before the session

1.1 *"To better understand what extraordinary experiences are, we also want to ask you about some mystical experiences you may have had.*

1.2 "*How would you describe mystical experiences in your own words*?"

Follow up with clarification on the characteristics participants report.

1.3 *"How do you think these experiences come to be? Do you think the cause of these experiences can be explained through science?"* Follow up to understand whether participants think mystical experiences involve a higher power and whether they think these experiences are fabricated.

2. Explanation of mystical experiences

Participants will be shown a video explaining the characteristics of mystical experiences and their causes.

3. Probe previous mystical experiences

3.1 *"Now that you know what mystical experiences can be like: How many mystical type experiences have you had in your life?"*

If multiple are mentioned, ask for the participant to describe their two most intense experiences by repeating the following questions.

3.2 *"Let's take a moment to go back to this experience. When was this experience? Where was it? Can you describe your surroundings/this place? In what context did you have this experience? What might have been the cause of this experience?"* Follow up on what psychedelic.

3.3 *"If you think about the part of the experience that you would describe mystical, what was this experience like?"*

3.4 *"Which thoughts came to mind during the experience?"*

3.5 *"Which feelings came to mind during the experience?"*

3.6 *"At the point of your mystical experience, did you see/hear/feel anything?"*

3.7 *"When you were having this experience, how did your body/time/space feel?"*

3.*8 "When you were having this experience, how did you perceive your sense of self?"* Follow-up if/how this is different from their normal sense of self.

3.9 *"How did you make sense of this experience while it was happening? How did you interpret or rationalize it afterwards?"*

If multiple mystical experiences are mentioned in 3.1 question, ask the following:

3.10 *"How did these experiences differ from one another?"*

3.11 *"What did the experiences have in common?"*

3.12 *"Here are some keywords describing the experiences you just talked about. Please think of any other mystical experiences you've had, assign a keyword, and rank them together with the ones we talked about from most intense or extraordinary to least intense. If you have had many mystical experiences, please write your top 10."*

4. God helmet suggestion

Video explanation of what the so-called Persinger helmet is and how it can sometimes lead to mystical experiences.

5. After the God Helmet session

Go through each moment they indicated as "unusual" with the button press with the following questions:

5.1 *"'Now let's go back to what happened at the first [or second, third etc.] button press. What did you experience here? Please start at the beginning, try to put the experiences in order"*

5.2 *"Which thoughts and feelings came to mind during the experience?"*

5.3 *"When you were having this experience, did you see/hear/feel anything?*

5.4 *"When you were having this experience, how did your body/time/space feel?"*

5.5 "*When you were having this experience, how did you perceive your sense of self?* Follow-up if/how this is different from their normal sense of self.

Let participants fill out the Self-Assessment Manikin for each button press.

After this, ask the following questions about the experiences taken together:

5.6 *"How do you make sense of the experiences during the experiment. How do you interpret them?"*

5.7 *"How did these experiences differ from the experience(s) we talked about before the experiment?"*

5.8 *"What did the experiences have in common? Do you think they are comparable?"*

5.9 "*On a scale from 1-5, how much do you think the experiences are comparable?"*

1 = not at all, they were completely different

2 = there may have been some similarities, but I'm not sure

3 = slightly comparable, there were a few similarities

4 = very comparable, the experience reminded me of the other

5 = identical, I felt like I was reliving a previous experience

5.10 *"Think of yourself daydreaming, for example when you get lost in thoughts or you are lost in imagination. Were the experiences with the helmet similar to that?"*

5.11 *"How strong or intense was the experience with the helmet compared to daydreaming?"*

5.12 *"Were there moments where your experience was similar to daydreaming and parts where it wasn't, or was the whole experience the same?"*

5.13 *"Here is the list of mystical experiences you filled in at the beginning of this session. Please think of where in this list you would place your experience with the helmet and place it there."*

5.14 Fill out the Hood's Mysticism Scale

Participants will be invited to elaborate on the items of the Hood's Mysticism Scale in the interview, as well as to discuss any other aspects of the experience.

5.15 Fill out the Altered Self-Consciousness Questionnaire

5.16 Questions by Griffiths et al. (2006, see Appendix 1.4)

Follow-up 1 day after the session

1. *"This is the list of mystical experiences that you filled in at the end of the session in the lab. Does the experience with the Persinger Helmet still rank in the same place in relation to these experiences?"*

2. Fill in the Flourishing Scale

3. Questions from Griffiths et al. (2006, see Appendix 1.4)

Follow-up 1 week after the session

1. *"This is the list of mystical experiences that you filled in at the end of the session in the lab. Does the experience with the Persinger Helmet still rank in the same place in relation to these experiences?"*
2. Fill in the Flourishing Scale
3. Questions from Griffiths et al. (2006)

Follow-up 1 month after the session

1. *"This is the list of mystical experiences that you filled in at the end of the session in the lab. Does the experience with the Persinger Helmet still rank in the same place in relation to these experiences?"*
2. Fill in the Flourishing Scale
3. Questions from Griffiths et al. (2006)
4. *"Did you look up information about the Persinger Helmet in the past weeks (e.g., on the internet)? If so, how many days after the session with the helmet did you look it up? Did that change your opinion about what you experienced?"*
5. Manipulation check
    1. *"We are almost at the end of the study and we are curious to learn how you experienced the study. Please note anything you would like to share with us (in about 100-200 words)."*
    2. *"What do you think this study was about?"*
    3. *"The aim of this study was to understand how stimulation of the brain through a Persinger-helmet can result in ordinary and extraordinary experiences. To what extent did you feel the effects of the brain stimulation?"*
    4. *"Do you think the Persinger Helmet actually stimulated your brain?"*
    5. *"Please explain why you think so."*
    6. *"Do you think The Persinger Helmet is capable of inducing mystical experiences?"*
    7. *"Please explain why you think so."*

8. *"Do you think you were deceived in any way during this study?"*
9. *"How do you think you were deceived?"*

Other material

For the precise formatting of the questions used and the full procedure, see the following documents in the Open Science Framework pre-registration of this project (https://osf.io/sq4zr):

- Screening_pt1
- Screening_pt2
- Experiment_Questionnaire
- Follow-up_1d
- Follow-up_1w (identical to Follow-up_1d)
- Follow-up_1m_debrief
- Lab protocol + Interview

Appendix C

Qualitative Analysis Coding Tables

Table A1 shows a frequency table of the codes used for the qualitative analysis. Codes with a frequency lower than five are listed in the paragraphs following the table.

Table A1

Frequency of Codes that Emerged from the Interviews

Codes	Number of Participants
○ tingling	28
○ relaxed	23
○ floating	22
○ Reflection: falling asleep/drifting off comparison	21
○ anxiety	16
○ chill/cold	16
○ calm	15
○ Reflection: dreaming comparison	15
○ memories	14
○ hands feeling	13
○ legs feeling	13
○ Reflection: drug comparison	12
○ light	12
○ light feeling	12
○ friend/significant person	11
○ happy	11
○ head feeling	11
○ Reflection: meditation comparison	11
○ warm	11
○ colours	10
○ clear/vivid/felt real	9
○ heavy body	9
○ Reflection: mention placebo effect	9
○ presence	9
○ purple	9
○ both awake and asleep	8
○ daily thoughts	8
○ goosebumps	8
○ might be falling asleep	8
○ scary	8
○ wave of energy/sensations	8
○ black	7
○ face	7
○ Reflection: effects are maybe due to something other than helmet	7
○ lifting	7
○ light flash	7

○ music	7
○ physically numb	7
○ self/perspective changes	7
○ afraid	6
○ bright	6
○ chest feeling/pain	6
○ dark	6
○ glimpse/ fast image	6
○ green	6
○ Reflection: effects are maybe due to sensory deprivation	6
○ peaceful	6
○ pink	6
○ pushed down towards the chair	6
○ separated from time and space	6
○ sudden change	6
○ time fast	6
○ uncomfortable	6
○ vibration	6
○ weird (specific sensation)	6
○ white	6
○ whole body moving	6
○ arm feeling	5
○ blue	5
○ body compressed	5
○ curious	5
○ eyes	5
○ face sensation	5
○ fast	5
○ hearing talking	5
○ heartbeat	5
○ moving visual	5
○ shiver	5
○ silhouette	5
○ sinking	5
○ space expansive/massiv	5
○ tense body	5
○ waves carrying body up and down	5

Codes that appeared 4 times:

Body dissolution, breathing deeper, cartoon, comfortable, confused, different space, disappears with attention, feel solenoids changing, feeling of sound, heard metallic/electronic noise, hearing bird, hearing voice, insight, known person, nature, red, shaking/spasm, and stomach feeling, visuals (no explanation).

Codes that appeared 3 times:

Annoying, away from body, being loved, blackness, body awareness, body part moved, breath awareness, can't move, cave, cloud, dog, elastic feeling, euphoria, eye sensation, faces, fall forward, frustrating, head pulses, headache, hearing footsteps, helmet or not moving, helmet uncomfortable, hug, mountains, negative emotion in visual (not feeling negative), nice, not breathing, not feeling body, pattern visual, people, pressure, roller coaster comparison, sense of urgency, series/movie, shoulder sensation, space, spinning, Star Wars, street, tilting, time short, unusual, water, and yellow.

Codes that appeared 2 times:

Adrenaline, anger, bike, black and white, Blackmore video comparison, body changing, body expanding, boring, bubbling/wobbling, butterfly, cant control thoughts, chest sensation, circle, close to mystical, coming back to current space, control group, could not steer visuals, dead, downward movement, enjoyable, exciting, eye stroke sensation, falling, flashback to previous mystical experience, fluffy feeling, fun, funny, gelatine, getting out of body (but not quite), hair, in between sleep and awake, jaw clench/tightness, jump, jungle sounds, leg longer, letting go of control, massage, melting, morphing into each other, nauseous, not able to visualize normally, not aware of space, not very intense but something, one ongoing experience, outside, panic, pattern sensation in body, patting on body, pleasant, pushed sideways, rotating, sadness, sick in stomach, sitting still for long comparison, sleep paralysis comparison, slight pain/discomfort, smiling, someone wearing helmet, song, stars, stiff, strobe light, sudden stop, sunny day, surprised, temple, time disappeared, time slow, tired, tree, triangle, trippy, turned upside down body feeling, twitching, walking, warm and cold alternating, woman.

Codes that appeared once:

abdomen/genitals feeling, air/wind/blowing, airplane, alert, amused, animal, assembled and reassembled, at ease, backpack, ball, balloon, bear, beautiful, being watched, big bang, bike bell sound, blank space, blanket, body bending, body inflating/becoming bigger, body longer/bigger, bowling game, bright lights behind me, brightness, brown, can't distinguish when limb ends, cards, chair moving, changing shape, chaotic, chest getting bigger, chicken, children singing, chirp sound,

choking, cigarette, claustrophobic, comparison to swing in mid-air, consciousness change, contaminated/polluted scenery, content, cool and crisp and fresh, copper taste, dagger, danger, deer, desert, digital, dissociation, distracted by solenoids and couldn't get back into feeling, dizzy/twisting/falling to the side, dots, dress, eagle, Egypt, electric charge, elephant, energetic, exhausted, face skin melting, familiar, fascinating, feeling body, feeling observed, feeling of being a tree, feeling stuck, felt in control, felt like actual touching person, felt like I could smell person, felt like needed to focus to have experiences, felt own aura, felt pulses, fight or flight, figures moving like snakes, fire, fish, floating up and down, flying, food, foot feeling, Formula One, fox, frightened, frog, full moon, garden, ghost-like, gibberish, glass shape, golden, good company, grateful, great, grey, grey-goldish hue, hand was being held, hands with eyes, heard cricket insect, heard just my voice in a different voice, heard snoring, heard tennis match, hearing buzz, hearing chair sounds, hearing helicopter/plane, hearing thunder, heart, heater next to you comparison, heating sound, heaven, hungry, image of myself, in veins/lungs/blood, intense, itchy, joyful, knee sensation, knocking on the door, laughter, light in the distance, light spots raining down, light turning on and off, lightning, lines, lucid dream, mellow, mention falling asleep, merry go rounds, metal construction, metallic ledge, meteors, mixture of light and heaviness, mobile phone, mosaic, moving fast through starfield, moving through tunnel/caves, muscle spasm/contracting, music drums, my reflection, need to open eyes to check, neon, nervous, night sky, no feeling in legs, northern lights, nostalgia, not feeling chair, not here in this space, not in control of body, ocean, one with all, orange, pain disappeared, parrot, pass through body, person, person biting apple, phone calling, physical effort, planet, playfulness, police car, pulling, rabbit, rain, rectangle, restless, ringing in ear, ripples, ritual, river, rocking back and forth, scooter, seeing emotions clearly, seeing sea waves, self disappearing, self normal, sensation/sound in one ear, serenity, sexual arousal, shadow, sharp pain, shrinking toward inside of themselves, skin peeled off, skull, skyline, smell, smile, someone breathing on body part, something pushing through, sound (not explained), sound of cars diving in the rain, space big, space moving, space normal, space smaller, space whale, spaceships, sparks, sphere, spots, squeezing

interrupted experience, stinging feeling, stop motion, strange thing feeling of utterly normal, statoscope, stretching feeling, string, sudden darkness, surrender, tai chi, tears/cried, tennis court, and tense and relaxed alternating, thoughts building on each other, thrilled, throat sensation, thumb sensation, ticking noise, time and space the same, time endless, tipi tent, tomb, train, trance, trying to trigger hallucinations but didn't work, trumpet music, trying to get into receptive state, tunnel, unnatural body position, unnatural movement in the visual, unnerving, urban structures forming a man, vampire, vase, video game, vignette visual field, vision perspective only in front, visual of self floating, visuals amplified, vortex, vulnerable, walking outside, wall street, want to get back into previous moment, weird face, welcomed, wheel, whistling sound, white noise changing, white static visual, whoosh sound, wonder/awe, yawning, and zooming in.

Appendix D

R Code

Cleaning Up and Exploring Data

```
#### Load packages and functions ####

library(readxl)

library(psych)

library(readxl)

library(plyr)

library(janitor)

library(tomoda)


getmode <- function(v) {

  uniqv <- unique(v)

  uniqv[which.max(tabulate(match(v, uniqv)))]

}


#### Clean up data and explore data ####


##### SCREENING QUESTIONNAIRE #####

# Load data

data <- read_excel("Screening2.xlsx")


# Remove first row

data <- data[-1,]


### Clean data: Select participants that participated in the end ###


# Load sheet with participants who participated in the end
```

```
all_participants <- read_excel("log sheet.xlsx")
all_ppnr <- all_participants$ppnr
all_ppnr <- all_ppnr[4:84] # Remove pilots


# Loop to select participants who participated (copy rows of
participant numbers that are correct into new data frame)
newdata_sc <- data.frame()
for (i in 1:length(all_ppnr)){
  selected_ppnr <- all_ppnr[i]
  newdata_sc <- rbind(newdata_sc, data[which(grepl(selected_ppnr,
data$ppnr)>0),])
  }


# Remove participants who didn't finish helmet session
newdata_sc <- newdata_sc[-(which(newdata_sc$ppnr ==
"R_30pHhvjRx8nih5c")),]
# There's 2 rows with this ppnr who dropped out, seems like he
filled the screening questionnaire in twice

### Save cleaned-up file ###
save(newdata_sc, file = "Screening2_clean")

### Explore descriptive variables ###
# Select SES, Gender, and Age columns

HighEd <- as.numeric(newdata_sc$`Highest education_1`)
```

```
Ladder <- as.numeric(newdata_sc$Ladder_1)

Age <- as.numeric(newdata_sc$Age_1)

Gender <- as.numeric(newdata_sc$Gender)


## Descriptives:  mean, SD, modal response


## Highest Education ##

# 1 = lower than high school diploma

# 2 = high school diploma

# 3 = some college credit but no diploma

# 4 = bachelor's degree

# 5 = master's degree

# 6 = doctorate degree (PhD)

describe(HighEd)

getmode(HighEd)


table(HighEd)

hist(HighEd)

# mean HighEd = 3.52, median = 4, mode = 4. Only 1 1 and 1 6.

Relatively normal distribution.


15/79  #19% high school

18/79 #22.7% some college

33/79 #41.8% bachelor's

11/79  #13.9% master's



describe(Ladder)
```

```
getmode(Ladder)


table(Ladder)
hist(Ladder, xlim = c(0,100), breaks = 100)
hist(Ladder, breaks = 7)
# mean Ladder = 60.71, median = 63, mode = 75. minmax (20,92)


# Most participants score between 60 and 80. relatively normal, but
lowering in the middle
# Range was between 20 and 92


# Bin participants to see how many in each range group #
# Bin participants in groups of 20
Ladder_0020 <- Ladder[Ladder >= 00 & Ladder <20]
Ladder_2040 <- Ladder[Ladder >= 20 & Ladder <40]
Ladder_4060 <- Ladder[Ladder >= 40 & Ladder <60]
Ladder_6080 <- Ladder[Ladder >= 60 & Ladder <80]
Ladder_80100 <- Ladder[Ladder >= 80 & Ladder <=100]


length(Ladder_0020)
length(Ladder_2040)
length(Ladder_4060)
length(Ladder_6080)
length(Ladder_80100)


# Bin in groups of 10
Bin10 <- NULL
Ladder_0020 <- Ladder[Ladder >= 00 & Ladder <20]
```

```
Ladder_2030 <- Ladder[Ladder >= 20 & Ladder <30]

Ladder_3040 <- Ladder[Ladder >= 30 & Ladder <40]

Ladder_4050 <- Ladder[Ladder >= 40 & Ladder <50]

Ladder_5060 <- Ladder[Ladder >= 50 & Ladder <60]

Ladder_6070 <- Ladder[Ladder >= 60 & Ladder <70]

Ladder_7080 <- Ladder[Ladder >= 70 & Ladder <80]

Ladder_80100 <- Ladder[Ladder >= 80 & Ladder <=100]


length(Ladder_0020)

length(Ladder_2030)

length(Ladder_3040)

length(Ladder_4050)

length(Ladder_5060)

length(Ladder_6070)

length(Ladder_7080)

length(Ladder_80100)


## Age ##

# age = 1 = 17 or younger; 2 = 18-24; 3 = 25-34; 4 = 35-45; 5 = 45+

# 1 and 5 excluded

describe(Age)


table(Age)

32/79 #40% 18-24 y/o

37/79 #46.3% 25-34 y/o

10/79 #12.5% 35-45 y/o


## Gender ##
```

```
# 1 = male, 2 = female, 3 = other, 4 = prefer not to say
describe(Gender)

table(Gender)
hist(Gender, ylim = c(0,50))

## Meditation experience ##
#  1 = yes, 2 = no
table(newdata_sc$Meditationexp)

## Psychedelic experience ##
# 1 = yes, 2 = no
table(newdata_sc$Psychedelicsexp)

## How frequently do you take psychedelics ##
# 1 = Once every few years, 2 = 1-5 times a year, 4 = More than 10
times a year,  7 = About once a year, 8 = 5-10 times a year
table(newdata_sc$Psychedelicsfreq)

## Social desirability (10-item version from Strahan & Gerbasi,
2006) ##
social_des <- as.data.frame(sapply(newdata_sc[,76:85], as.numeric))

# 10 = Strongly disagree
# 11 = Disagree
# 12 = Neither agree nor disagree
# 13 = Agree
# 14 = Strongly agree
```

```
# Recode to 1-5 scale
social_des <- social_des - 9

# Reverse the reverse coded items
S_neg <- c(6, 7, 8, 9, 10)
for (i in 1:length(S_neg)){
  q <- S_neg[i]
  social_des[,q] <- 6 - social_des[,q]
}

# OPTIONAL: transform to 1 and 0s
social_des[social_des == 1] <- 0
social_des[social_des == 2] <- 0
social_des[social_des == 3] <- 0
social_des[social_des == 4] <- 1
social_des[social_des == 5] <- 1

# Cronbach's alpha
library("ltm")
cronbach.alpha(social_des, CI = T)

# Calculate scores
social_des$SocialScore <- unlist(rowSums(social_des)) # calculate
score for each participant
social_des$ppnr <- newdata_sc$ppnr # add participant number row
save(social_des, file = "social_des") #save data frame with all the
scores
```

```
# Descriptives
mean(social_des$SocialScore) # with T/F = 4.46 (sd = 1.99), with 1-5
scale = 31.77 (sd = 5.32)
sd(social_des$SocialScore)

# Make histogram of scores
hist(social_des$SocialScore, breaks = 10)

y <- hist(social_des$SocialScore, breaks = 10,
          main="Social Desirability (higher better)",
          xlab="Score (additive)",
          xlim=c(0,10),
          ylim = c(0,20),
          col = 'darkorchid1',
          xaxp=c(0,10,10))

text(y$mids,y$counts,labels=y$counts, adj=c(0.5, -0.5))



##### EXPERIMENT QUESTIONNAIRE #####
#load data
data_exp <- read_excel("ExperimentQuestionnaire.xlsx")

# remove first row
data_exp <- data_exp[-1,]

### Clean data: select the ones that participated in the end ###
```

```
# Loop to select participants who participated (copy rows of ppnrs
that are correct into new df)
newdata_exp <- data.frame()
for (i in 1:length(all_ppnr)){
  selected_ppnr <- all_ppnr[i]
  newdata_exp <- rbind(newdata_exp,
data_exp[which(grepl(selected_ppnr, data_exp$ppnr)>0),])
}


# Remove doubles (participant started filling in questionnaire
twice)
which(newdata_exp$ppnr == "R_2tkYy57aTiN0g5R") # Find participant
(rows 26 + 27)
View(newdata_exp[26:27,])

# Remove row that wasn't finished
newdata_exp <- newdata_exp[-26,]


# Remove participant who didn't finish helmet session (has the wrong
participant number by mistake)

which(newdata_exp$ppnr == "R_1rcfeFwFVq4GA1P") # Find participant
(rows 26 + 27)
View(newdata_exp[71:72,]) # row 72 didn't finish the session
```

```
# Remove row that wasn't finished
newdata_exp <- newdata_exp[-72,]


### Clean data: Add amount of previous Mystical Experiences ###
rank1 <- newdata_exp[,18:27] # Select columns with Ranking1
previousME <- NULL

for (i in 1:length(newdata_exp$ppnr)){
  #for each participant, get length of rank list (= how many
previous Mystical Experiences)
  pp <- rank1[i,]

  if (sum(is.na(pp)) == 0){ # if there are no NAs, count
    total <- length(pp)
  } else {
    total <- length(pp[-which(is.na(pp))]) # if there are NAs,
exclude NAs and count
  }

  previousME <- append(previousME, total) # Add number of previous
Mystical Experiences to same variable
}

newdata_exp$previousME <- previousME # Add variable to data frame
with other data
```

```
### Clean data: Edit wrong ranking values ###

rank1 <- newdata_exp[,18:27] # Select columns with Ranking 1
rank2 <- newdata_exp[,40:50] # Select columns with Ranking 2

    # Ranking 2- godhelm_1 = Persinger helmet
    # the rest are experiences 1-10


# Check which participants had 0 previous mystical experiences
which(is.na(rank1$`Ranking 1 fill_1`)) #check if Experience 1 = NULL
(Experience 1 = `Ranking 1 fill_1`)

# 7 39 57 61 69 have had no previous MEs, so 79-5 = 74 participants
had previous MEs

# Check which participants have missings in god helmet ranking
which(is.na(rank2$`Ranking 2- godhelm_1`))
# 7 13 16 17 37 39 55 57 61 69 -> Manually checked on the table.
Some participants left the ranking as it is without clicking on the
screen, and therefore qualtrics didn't record a response

# Remove the ones with no previous ME gives:  13 16 17 37 55 did not
record response

View(newdata_exp[13,]) # R_UiEvhfT6KZtQ4hP had to leave after helmet
session, no rank2
```

```
# Edit responses to match standard ranking when no input is given
View(newdata_exp[16,]) # 1 previous ME
newdata_exp[16,40] <- "1.0"
newdata_exp[16,41] <- "2.0"

View(newdata_exp[17,]) # 5 previous MEs
newdata_exp[17,40] <- "1.0"
newdata_exp[17,41] <- "2.0"
newdata_exp[17,42] <- "3.0"
newdata_exp[17,43] <- "4.0"
newdata_exp[17,44] <- "5.0"
newdata_exp[17,45] <- "6.0"

View(newdata_exp[37,]) # 2 previous MEs
newdata_exp[37,40] <- "1.0"
newdata_exp[37,41] <- "2.0"
newdata_exp[37,42] <- "3.0"

View(newdata_exp[55,]) # 7 previous MEs
newdata_exp[55,40] <- "1.0"
newdata_exp[55,41] <- "2.0"
newdata_exp[55,42] <- "3.0"
newdata_exp[55,43] <- "4.0"
newdata_exp[55,44] <- "5.0"
newdata_exp[55,45] <- "6.0"
newdata_exp[55,46] <- "7.0"
newdata_exp[55,47] <- "8.0"
```

```
### Descriptives for Previous Mystical Experiences ###
previousME <- newdata_exp$previousME

describe(previousME)

table(previousME)
hist(previousME)



### M-Scale ###

View(newdata_exp[,51:82]) # Check visually for strange response
patterns

Mscale <- newdata_exp[,51:82] # Select M-scale columns

# Make columns numeric
for (i in 1:length(Mscale)){
  Mscale[,i] <- as.numeric(unlist(Mscale[,i]))
}

# Reverse score of negatively phrased items
M_neg <- c(2, 6, 7, 8, 9, 10, 14, 15, 16, 21, 24, 25, 26, 27, 28,
30)

for (i in 1:length(M_neg)){
  c <- M_neg[i]
  Mscale[,c] <- 6 - Mscale[,c]
```

```
}

# Calculate total score
Mscore <- rowSums(Mscale)

newdata_exp$Mscore<- Mscore

save(newdata_exp, file = "newdata_exp")

# Descriptives
describe(Mscore)
getmode(Mscore)

hist(Mscore, breaks = 78, xlim = c(25,160))
```

Threshold Approach

```
### Load packages ####
library("car")
library("RColorBrewer")
library("tidyverse")
library("psych")


## Load gripper data ####
# Reading txt file
acqdata <-read.delim("Gripper_highpass1.txt")
```

```
acqdata$Epoch_ID <- sub(".*R_", "", acqdata$Epoch_ID)
acqdata$Epoch_ID <- sub(").*", "", acqdata$Epoch_ID)
acqlist <- split(acqdata, acqdata$Epoch_ID)
View(acqlist)

#rename wrongly named participants (sub function doesnt work well if
ppnr ends in R)
names(acqlist)[1] <- "R_2tkYy57aTiN0g5R"
names(acqlist)[which(names(acqlist) == "4-4-2022_1500")] <-
"R_3nVndgfpUAkRObR"



# Add participant that was not in the file
acqdata_2 <-read.delim("Gripper_extra_highpass1.txt")

acqdata_2$Epoch_ID <- sub(".*R_", "", acqdata_2$Epoch_ID)
acqdata_2$Epoch_ID <- sub(").*", "", acqdata_2$Epoch_ID)
acqlist_2 <- split(acqdata_2, acqdata_2$Epoch_ID)

acqlist[names(acqlist_2)[3]] <- acqlist_2[3]

save(file = "acqlist_highpass1", acqlist)

#### Loading data ####
HelmetExp <- read_excel("HelmetExp.xlsx")
load("acqlist_highpass1")
```

```
#### Get amount of presses with threshold approach and strongest
press ####

library(pracma)

for (i in 1:length(acqlist)){

    #### Select data for participant #i ####

    # Create variable with first 12 characters of participant number
(ppnr) #i in acqlist
    ppnr_part <- substr(names(acqlist[i]), 1, 12)

    # Check which row in HelmetExp belongs to this participant
number
    HelmetExp_row <- grep(ppnr_part,HelmetExp$ppnr)

    # Load data for selected participant
    Gripper <- as.data.frame(acqlist[i])

    # Select relevant rows and name columns
    Gripper <- Gripper[4:nrow(Gripper),]
    colnames(Gripper) <- c("Epoch_ID", "startTime", "endTime",
"duration", "epochName",
                "dataSource", "epochSource", "startActualValue",
"startActualOccur", "startActualDelay",
                "startActualDur", "endActualValue", "endActualOccur",
"endActualDelay", "endActualDur",
```

```
            "time_Global", "time_Epoch", "Filtered_Signal" )

    #### Defining Baseline ####
    Gripper_Baseline <- Gripper[grep("Baseline", Gripper$epochName),
] # Select data from baseline period

    x_baseline <- as.numeric(Gripper_Baseline$Filtered_Signal) #
Make variable with only gripper strength data

    x_baseline_sq <- x_baseline^2 # Square all data to improve
signal to noise ratio

    #### Defining Experiment Signal ####
    Gripper_Experiment <- Gripper[grep("Epoch", Gripper$epochName),
] # Select data from experiment period

    x_experiment <- as.numeric(Gripper_Experiment$Filtered_Signal)

    x_experiment_sq <- x_experiment^2

    # Calculate mean presses and standard deviation
    exp_mean <- describe(x_experiment_sq)$mean
    exp_sd <- describe(x_experiment_sq)$sd


    ####Defining peaks with threshold ####
    # Find peaks 3 standard deviations above the mean
```

```
    peaks_exp <- findpeaks(x = x_experiment_sq, minpeakheight =
exp_mean+3*exp_sd, minpeakdistance = 500)

    # Add peaks to HelmetExp
    HelmetExp$threshold[HelmetExp_row] <- nrow(peaks_exp)

    #### Corrected strongest press ####
    # Calculate the strongest button press corrected for strength of
grip
    max_corrected <- max(x_experiment) / max(x_baseline)

    # Add strongest press to HelmetExp
    HelmetExp$max_gripper[HelmetExp_row] <- max(x_experiment)
    HelmetExp$max_corrected[HelmetExp_row] <- max_corrected

}


#### Clean data file ####

# Check if there are participants with 0 presses in threshold count
that should have some according to interview
which(HelmetExp$threshold == "0") # Not the case, all good.

# Put 0's instead of NA's in HelmetExp$threshold when participant
had 0 presses
HelmetExp$threshold[c(which(HelmetExp$counting_interview == 0))] <-
0
```

```
# Check missing data
HelmetExp$threshold[which(is.na(as.numeric(HelmetExp$threshold)))]
    #R_1XoW3P0dQnCeIBX had a mixup and can't find corresponding
files. The rest are 2 missing files and 1 error while saving

# Make numeric
HelmetExp$threshold <- as.numeric(HelmetExp$threshold)

# If participant presses at beginning and at end, count by half
which(HelmetExp$pressed_before_after != "NA") #48, 60
HelmetExp$pressed_before_after[c(48,60)] #only participant nr. 60
pressed before and after for all grips
HelmetExp$threshold[60] <- as.numeric(HelmetExp$threshold[60]) / 2


# Remove strings and make counting_interview numeric
which(is.na(as.numeric(HelmetExp$counting_interview))) #3,48,73
HelmetExp$counting_interview[c(3,48,73)]
HelmetExp$counting_interview[3] <- 3
HelmetExp$counting_interview[48] <- 3
HelmetExp$counting_interview[73] <- 5

HelmetExp$counting_interview <-
as.numeric(HelmetExp$counting_interview)

#### Descriptives ####
# Number of presses: counting vs threshold approach
```

```
psych::describe(as.numeric(HelmetExp$counting_interview), na.rm = T)
psych::describe(as.numeric(HelmetExp$threshold), na.rm = T)

table(HelmetExp$threshold)
remove_row <- which(HelmetExp$threshold == 145)
HelmetExp$threshold[remove_row] <- NA

save(file = "HelmetExp_new_highpass1_sq", HelmetExp)
```

Multivariate Linear Regression

```
#### Load packages ####
library("car")
library("RColorBrewer")
library("tidyverse")
library("psych")

#### Load all data into same file ####

load("Final_HelmetExp_sq_highpass1")
load("newdata_exp")


# Check if same participants in both files
which(HelmetExp$ppnr != newdata_exp$ppnr) # One more row in newdata,
number 80
newdata_exp$ppnr[80] # "R_3HN571iZf9taXi9", somehow we lost all
other data except the online questionnaires. Exclude.
```

```
# Exclude R_3HN571iZf9taXi9 and load the rest of the data (number of
previous ME + Mscale) into HelmetExp
HelmetExp$previousME <- newdata_exp$previousME[-80]
HelmetExp$Mscore <- newdata_exp$Mscore[-80]



#### INSPECT DATA ####

#* inspect, histograms ####

describe(HelmetExp[,c("counting_interview", "threshold",
"max_corrected", "Mscore", "previousME")])
# no extreme means and sd
# range is very different

hist(HelmetExp$max_corrected) #skewed to the right, people tend to
press lightly, can be interpreted as not very strong experiences
hist(HelmetExp$threshold) #skewed to the right, only a few people
had very many exp, makes sense
hist(HelmetExp$counting_interview) #skewed to the right, similar to
threshold (but much lower values )
hist(HelmetExp$previousME) #not normal, kind of straight line,
indicates heterogeneous sample. Fine.
hist(HelmetExp$Mscore) #skewed to the right, only a few people had
mystical experiences, makes sense

#* scale variables ####
```

```
# Range of scale is small for max_gripper(0.92) compared to other
variables, so scale it.

HelmetExp$max_gripper_scaled <- HelmetExp$max_corrected * 10
describe(HelmetExp$max_gripper_scaled)



#* look at correlations ####
# check correlations above 0.5
cor(x = HelmetExp[,c("threshold", "counting_interview",
"max_gripper_scaled", "Mscore", "previousME")], use =
"pairwise.complete.obs")

library("Hmisc")
rcorr(x = as.matrix(HelmetExp[,c("threshold", "counting_interview",
"max_gripper_scaled", "Mscore", "previousME")]))

#* scatterplot ####
plot(HelmetExp[,c("threshold", "counting_interview",
"max_gripper_scaled", "Mscore", "previousME")])

# Same plot divided by number of previous MEs
plot(HelmetExp[,c("threshold", "counting_interview",
"max_gripper_scaled", "Mscore")],
     col = HelmetExp$previousME, pch = 1)

library(GGally)
library(dplyr)
```

```
HelmetExp %>% select("threshold", "counting_interview",
"max_gripper_scaled", "Mscore", "previousME") %>% ggpairs(
  aes(colour = as.factor(HelmetExp$previousME), alpha = .1))

#* Boxplots ####
par(mfrow=c(2, 2))
Boxplot(counting_interview ~ previousME, data=HelmetExp)
Boxplot(threshold ~ previousME, data=HelmetExp)
Boxplot(max_gripper_scaled ~ previousME, data=HelmetExp)
Boxplot(Mscore ~ previousME, data=HelmetExp)

# Decision not to remove outliers, because its not the same person
in all plots and no theoretical basis to do it



#### REGRESSION ####
#α = 0.0125 (bonferroni)

fit_counting <- lm(counting_interview ~ previousME, data =
HelmetExp)
fit_threshold <- lm(threshold ~ previousME, data = HelmetExp)
fit_max_gripper <- lm(max_gripper_scaled ~ previousME, data =
HelmetExp)
fit_Mscore <- lm(Mscore ~ previousME, data = HelmetExp)

summary(fit_counting)
summary(fit_threshold)
summary(fit_max_gripper)
```

```
summary(fit_Mscore)


#### CHECK ASSUMPTIONS####


#* homoscedasticity ####


#all look fine
par(mfrow=c(2, 2))
plot(fitted(fit_counting), resid(fit_counting))
abline(0,0)
plot(fitted(fit_threshold), resid(fit_threshold))
abline(0,0)
plot(fitted(fit_max_gripper),resid(fit_max_gripper))
abline(0,0)
plot(fitted(fit_Mscore), resid(fit_Mscore))
abline(0,0)


#* linearity ####
#looks nice
par(mfrow=c(2, 2))
crPlots(fit_counting)
crPlots(fit_threshold)
crPlots(fit_max_gripper)
crPlots(fit_Mscore)


# normal scatterplots -> seem linear enough
plot(HelmetExp$previousME, HelmetExp$counting_interview)
plot(HelmetExp$previousME, HelmetExp$threshold)
```

```
plot(HelmetExp$previousME, HelmetExp$max_gripper_scaled)
plot(HelmetExp$previousME, HelmetExp$Mscore)

#* normality of residuals (multivariate normality) and
autocorrelation ####
# Q-Q plot for residuals
par(mfrow=c(2, 2))

qqnorm(resid(fit_counting), main = "Counting Q-Q Plot") #seems ok
enough
qqline(resid(fit_counting))

qqnorm(resid(fit_threshold), main = "Threshold Q-Q Plot") #not great
qqline(resid(fit_threshold))

qqnorm(resid(fit_max_gripper), main = "Max Gripper Q-Q Plot")
#doesnt look good at the end
qqline(resid(fit_max_gripper))

qqnorm(resid(fit_Mscore), main = "M Score Q-Q Plot") #ok enough
qqline(resid(fit_Mscore))


# density plot of residuals
par(mfrow=c(2, 2))
plot(density(resid(fit_counting)), main = "Density Counting") #close
to normal, a bit skewed to the right
```

```
plot(density(resid(fit_threshold)), main = "Density Threshold")
#skewed to the right
plot(density(resid(fit_max_gripper)), main = "Density Max Gripper")
#strange thing at the right tail
plot(density(resid(fit_Mscore)), main = "Density M score") #well
centered but heavy on left side so also skewed to right

hist(resid(fit_counting))
hist(resid(fit_threshold))
hist(resid(fit_max_gripper))
hist(resid(fit_Mscore))

# Doesn't look too good, so I did nonparametric test as well for
robustness
library(olsrr)
ols_test_normality(fit_counting)
ols_test_normality(fit_threshold)
ols_test_normality(fit_max_gripper)
ols_test_normality(fit_Mscore)

# All tests except for K-S are significant, and K-S gives error for
ties so not good to rely on it
# Assumption of normality not met, same analysis with transformed
variables performed below (p.)


#* multicollinearity ####
```

```
cor(x = HelmetExp[,c("threshold", "counting_interview",
"max_gripper_scaled", "Mscore", "previousME")], use =
"complete.obs")
library("corrplot")
corrplot(cor(x = HelmetExp[,c("threshold", "counting_interview",
"max_gripper_scaled", "Mscore", "previousME")], use =
"complete.obs"), method = "number")

#* autocorrelation ####
#Durbin-Watson's d tests for autocorrelation/ independence of
resuiduals
library(lmtest)
dwtest(fit_counting ,  alternative = "two.sided") #DW=1.94, p = 0.79
dwtest(fit_threshold ,  alternative = "two.sided") #DW = 1.98, p =
0.93
dwtest(fit_max_gripper ,  alternative = "two.sided") # DW = 1.95, p
= 0.82
dwtest(fit_Mscore ,  alternative = "two.sided") #DW = 2.037, p =
0.89
#no autocorrelation, as 1.5 < d <2.5

plot((resid(fit_counting)))
plot((resid(fit_threshold)))
plot((resid(fit_max_gripper)))
plot((resid(fit_Mscore)))



#### Confidence intervals and plots####
```

```
confint(fit_counting, parm = 'previousME', level = 0.95)
confint(fit_threshold, parm = 'previousME', level = 0.95)
confint(fit_max_gripper, parm = 'previousME', level = 0.95)
confint(fit_Mscore, parm = 'previousME', level = 0.95)

# Plot CI lines
library(ggplot2)

ggplot(fit_counting, aes(x=previousME, y=counting_interview)) +
  geom_point(color='#2980B9', size = 1) +
  geom_smooth(method=lm, color='#2C3E50') +
  ylab("Counting") +
  xlab ("Previous ME")

ggplot(fit_threshold, aes(x=previousME, y=threshold)) +
  geom_point(color='#2980B9', size = 1) +
  geom_smooth(method=lm, color='#2C3E50') +
  ylab("Threshold") +
  xlab ("Previous ME")

ggplot(fit_max_gripper, aes(x=previousME, y=max_gripper_scaled)) +
  geom_point(color='#2980B9', size = 1) +
  geom_smooth(method=lm, color='#2C3E50') +
  ylab("Strength") +
  xlab ("Previous ME")

ggplot(fit_Mscore, aes(x=previousME, y=Mscore)) +
```

```
  geom_point(color='#2980B9', size = 1) +
  geom_smooth(method=lm, color='#2C3E50') +
  ylab("M-scale Score") +
  xlab ("Previous ME")


#### Social desirability scale ####
# Social desirability (10-item version from Strahan & Gerbasi, 2006)
load("Screening2_clean")
social_des <- as.data.frame(sapply(newdata_sc[,76:85], as.numeric))

# Change coding to 1-5 scale
social_des <- social_des - 9

# Reverse the reverse coded items
S_neg <- c(6, 7, 8, 9, 10)
for (i in 1:length(S_neg)){
  q <- S_neg[i]
  social_des[,q] <- 6 - social_des[,q]
}

social_des$SocialScore <- unlist(rowSums(social_des)) # calculate
score for each participant
social_des$ppnr <- newdata_sc$ppnr # add participant number row

library("dplyr")
HelmetExp_social <- inner_join(HelmetExp, social_des, by = "ppnr")
```

```
# Add as covariate to regression analyses

fit_counting_social <- lm(counting_interview ~ previousME +
SocialScore, data = HelmetExp_social)
fit_threshold_social <- lm(threshold ~ previousME + SocialScore,
data = HelmetExp_social)
fit_max_gripper_social <- lm(max_gripper_scaled ~ previousME +
SocialScore, data = HelmetExp_social)
fit_Mscore_social <- lm(Mscore ~ previousME + SocialScore, data =
HelmetExp_social)

summary(fit_counting_social)
summary(fit_threshold_social)
summary(fit_max_gripper_social)
summary(fit_Mscore_social)
# No effect of social desirability score on any of the variables



#### Follow-up 1 month ####
library(readr)
Followup1m <- read_csv2("Followup1m.csv") #load data
Followup1m <- Followup1m[-c(1,2),] #remove first two rows

### Clean up sheet ###

# Check how many unique participant numbers (i.e. ExternalReference)
are in the data
```

```
length(unique(Followup1m$ExternalReference))
# 2 missing entries, as well as double entries for
R_3nDIyhscN0cZ0iq, R_2VEdofpejeV1ddU, R_3KrrvhKfrcXBTwt,
R_UauGNQLZSAvNRfz and R_yOU3ZAPrSYJJRfj

# Check which of the double entries should be deleted
view(Followup1m[which(Followup1m$ExternalReference ==
c("R_3nDIyhscN0cZ0iq")), ]) #2nd not finished
which(Followup1m$ExternalReference == c("R_3nDIyhscN0cZ0iq")) #2nd
one is row 73
view(Followup1m[which(Followup1m$ExternalReference ==
c("R_2VEdofpejeV1ddU")), ]) #2nd also not finished
which(Followup1m$ExternalReference == c("R_2VEdofpejeV1ddU")) #2nd
one is row 74
view(Followup1m[which(Followup1m$ExternalReference ==
c("R_3KrrvhKfrcXBTwt")), ]) #also 2nd not finished
which(Followup1m$ExternalReference == c("R_3KrrvhKfrcXBTwt")) #2nd
one is row 72
view(Followup1m[which(Followup1m$ExternalReference ==
c("R_UauGNQLZSAvNRfz")), ]) #also 2nd not finished
which(Followup1m$ExternalReference == c("R_UauGNQLZSAvNRfz")) #2nd
one is row 76
view(Followup1m[which(Followup1m$ExternalReference ==
c("R_yOU3ZAPrSYJJRfj")), ]) #also 2nd not finished
which(Followup1m$ExternalReference == c("R_yOU3ZAPrSYJJRfj")) #2nd
one is row 75

# Check which entries are missing
```

```
which(is.na(Followup1m$ppnr)) #none

Followup1m <- Followup1m[-c(72,73,74,75,76),] #remove doubles and no
participant number

missing_followup1m <- HelmetExp$ppnr %in%
Followup1m$ExternalReference * 1
HelmetExp$ppnr[which(missing_followup1m == 0)] # missing follow-up
1m for 6 participants: #"R_UiEvhfT6KZtQ4hP" "R_2tkYy57aTiN0g5R"
"R_2rOeazRcIhg8P69" "R_2y3CNqOmWfOrGLQ" "R_3luESDJoNsG32c7"
"R_1GUMlmid4PcKeTs"

### Load flourishing scale ###
Flourishing <- as.data.frame(sapply(Followup1m[,29:36], as.numeric))

Flourishing$FlourishingScore1m <- unlist(rowSums(Flourishing)) #
calculate score for each participant
Flourishing$ppnr <- Followup1m$ExternalReference # add participant
number row

# Add Flourishing scale to data frame with all the data
library("dplyr")
HelmetExp_Flourishing <- inner_join(HelmetExp, Flourishing, by =
"ppnr")

### Load Flourishing scale at baseline ###
load("Screening2_clean")
```

```
FlourishingBaseline <- as.data.frame(sapply(newdata_sc[,86:93],
as.numeric))

FlourishingBaseline$FlourishingBaseline <-
unlist(rowSums(FlourishingBaseline)) # calculate score for each
participant
FlourishingBaseline$ppnr <- newdata_sc$ppnr # add participant number
row

# Add Flourishing scale to data frame with all the data
HelmetExp_Flourishing <- inner_join(HelmetExp_Flourishing,
FlourishingBaseline, by = "ppnr")

# Calculate difference score between Flourishing at baseline and at
1-month follow-up
HelmetExp_Flourishing$FlourishingDiff <-
HelmetExp_Flourishing$FlourishingScore1m -
HelmetExp_Flourishing$FlourishingBaseline


### Flourishing and M-scale regression ####
# Does the M-scale score predict difference in Flourishing scores
after 1 month?
describe(HelmetExp_Flourishing$FlourishingScore1m)

sum(is.na(HelmetExp_Flourishing$FlourishingScore1m)) #one
participant with NAs
```

```
fit_Flourishing <- lm(FlourishingScore1m ~ FlourishingBaseline +
Mscore + FlourishingBaseline:Mscore, data = HelmetExp_Flourishing,
na.action = na.omit)

plot(fit_Flourishing)
summary(fit_Flourishing)

# Look at data
plot(HelmetExp_Flourishing$FlourishingScore1m)
hist(HelmetExp_Flourishing$FlourishingScore1m, breaks = 10)

plot(HelmetExp_Flourishing$FlourishingBaseline)
hist(HelmetExp_Flourishing$FlourishingBaseline, breaks = 10)
# Assumptions
plot(HelmetExp_Flourishing$Mscore,
HelmetExp_Flourishing$FlourishingBaseline)
plot(HelmetExp_Flourishing$Mscore,
HelmetExp_Flourishing$FlourishingScore1m)
library(olsrr)
ols_test_normality(fit_Flourishing) # Non-significant SW and K-S.
All good.

qqnorm(resid(fit_Flourishing), main = "Flourishing-Mscore Q-Q Plot")
qqline(resid(fit_Flourishing))

# Density plot of residuals
plot(density(resid(fit_Flourishing)), main = "Density Flourishing-
Mscore") # A bit skewed to right
```

```
hist(resid(fit_Flourishing))


# Results: scatter plot with confidence interval lines
library(ggplot2)
ggplot(fit_Flourishing, aes(x=Mscore, y=FlourishingScore1m)) +
  geom_point(color='#2980B9', size = 1) +
  geom_smooth(method=lm, color='#2C3E50') +
  ylab("Flourishing One Month") +
  xlab ("M-Scale Score")


ggplot(fit_Flourishing, aes(x=FlourishingBaseline,
y=FlourishingScore1m)) +
  geom_point(color='#2980B9', size = 1) +
  geom_smooth(method=lm, color='#2C3E50') +
  ylab("Flourishing One Month") +
  xlab ("Flourishing Baseline")
summary(fit_Flourishing)



#### SAME REGRESSION WITH TRANSFORMED DATA####
# Transform dependent variables
# log transformation doesnt work well because of 0 values, so I do
square root transformation
HelmetExp$counting_interview_sqrt <-
sqrt(HelmetExp$counting_interview)
HelmetExp$threshold_sqrt <- sqrt(HelmetExp$threshold)
HelmetExp$max_corrected_sqrt <- sqrt(HelmetExp$max_corrected)
HelmetExp$Mscore_sqrt <- sqrt(HelmetExp$Mscore)
```

```
#* inspect, histograms ####
describe(HelmetExp[,c("counting_interview_sqrt",
"counting_interview", "threshold_sqrt", "threshold",
"max_corrected_sqrt", "max_corrected","Mscore_sqrt", "Mscore",
"previousME")])


par(mfrow=c(2, 2))
hist(HelmetExp$threshold)
hist(HelmetExp$threshold_sqrt)
hist(HelmetExp$counting_interview)
hist(HelmetExp$counting_interview_sqrt)

hist(HelmetExp$max_corrected)
hist(HelmetExp$max_corrected_sqrt)
hist(HelmetExp$Mscore)
hist(HelmetExp$Mscore_sqrt)

hist(HelmetExp$previousME)

#* look at correlations ####
# check correlation above 0.5
cor(x = HelmetExp[, c("threshold", "threshold_sqrt",
"counting_interview", "counting_interview_sqrt", "max_corrected",
"max_corrected_sqrt", "Mscore", "Mscore_sqrt", "previousME")], use =
"complete.obs")
```

```
#* scatterplot ####
plot(HelmetExp[,c("threshold", "counting_interview",
"max_corrected", "Mscore", "previousME")])
plot(HelmetExp[,c("threshold_sqrt", "counting_interview_sqrt",
"max_corrected_sqrt", "Mscore_sqrt", "previousME")])


# Scatterplot divided by number of previous MEs
plot(HelmetExp[,c("threshold", "counting_interview",
"max_corrected", "Mscore")],
     col = HelmetExp$previousME, pch = 1)

# Scatterplots look worse with sqrt- a lot of 0 values
plot(HelmetExp[,c("threshold_sqrt", "counting_interview_sqrt",
"max_corrected_sqrt", "Mscore_sqrt")],
     col = HelmetExp$previousME, pch = 1)

library(GGally)
library(dplyr)
HelmetExp %>% select("threshold_sqrt", "counting_interview_Sqrt",
"max_corrected_sqrt", "Mscore_sqrt", "previousME") %>% ggpairs(
      aes(colour = as.factor(HelmetExp$previousME), alpha = .1))

#* boxplots ####
par(mfrow=c(2, 2))
Boxplot(counting_interview ~ previousME, data=HelmetExp)
Boxplot(threshold ~ previousME, data=HelmetExp)
Boxplot(counting_interview_sqrt ~ previousME, data=HelmetExp)
```

```
Boxplot(threshold_sqrt ~ previousME, data=HelmetExp)

Boxplot(max_corrected ~ previousME, data=HelmetExp)
Boxplot(Mscore ~ previousME, data=HelmetExp)
Boxplot(max_corrected_sqrt ~ previousME, data=HelmetExp)
Boxplot(Mscore_sqrt ~ previousME, data=HelmetExp)

#### REGRESSION ####
#α = 0.0125 (bonferroni)

fit_counting <- lm(counting_interview ~ previousME, data =
HelmetExp)
fit_threshold <- lm(threshold ~ previousME, data = HelmetExp)
fit_max_gripper <- lm(max_corrected ~ previousME, data = HelmetExp)
fit_Mscore <- lm(Mscore ~ previousME, data = HelmetExp)

summary(fit_counting)
summary(fit_threshold)
summary(fit_max_gripper)
summary(fit_Mscore)

fit_sqrt_counting <- lm(counting_interview_sqrt ~ previousME, data =
HelmetExp)
fit_sqrt_threshold <- lm(threshold_sqrt ~ previousME, data =
HelmetExp)
fit_sqrt_max_corrected <- lm(max_corrected_sqrt~ previousME, data =
HelmetExp)
fit_sqrt_Mscore <- lm(Mscore_sqrt ~ previousME, data = HelmetExp)
```

```
summary(fit_sqrt_counting)

summary(fit_sqrt_threshold)

summary(fit_sqrt_max_corrected) # Now significant

summary(fit_sqrt_Mscore)


#### CHECK ASSUMPTIONS####


#* homoscedasticity (and also linearity?) ####


#all look fine

par(mfrow=c(2, 2))

plot(fitted(fit_sqrt_counting), resid(fit_sqrt_counting))

abline(0,0)

plot(fitted(fit_sqrt_threshold), resid(fit_sqrt_threshold))

abline(0,0)

plot(fitted(fit_sqrt_max_corrected),resid(fit_sqrt_max_corrected))

abline(0,0)

plot(fitted(fit_sqrt_Mscore), resid(fit_sqrt_Mscore))

abline(0,0)


#* linearity ####

#looks nice

par(mfrow=c(2, 2))

crPlots(fit_sqrt_counting)

crPlots(fit_sqrt_threshold)

crPlots(fit_sqrt_max_corrected)

crPlots(fit_sqrt_Mscore)
```

```
#normal scatterplots -> seem linear enough,
# Strange dots at 0 for counting and threshold but better this way
than with non-normal distributions
plot(HelmetExp$previousME, HelmetExp$counting_interview_sqrt)
plot(HelmetExp$previousME, HelmetExp$threshold_sqrt)
plot(HelmetExp$previousME, HelmetExp$max_corrected_sqrt)
plot(HelmetExp$previousME, HelmetExp$Mscore_sqrt)

#* normality of residuals (multiariate normality) and
autocorrelation ####
# Q-Q plot for residuals
par(mfrow=c(2, 2))

qqnorm(resid(fit_sqrt_counting), main = "Counting Q-Q Plot")
qqline(resid(fit_sqrt_counting))

qqnorm(resid(fit_sqrt_threshold), main = "Threshold Q-Q Plot")
qqline(resid(fit_sqrt_threshold))

qqnorm(resid(fit_sqrt_max_corrected), main = "Max Gripper Q-Q Plot")
qqline(resid(fit_sqrt_max_corrected))

qqnorm(resid(fit_sqrt_Mscore), main = "M Score Q-Q Plot")
qqline(resid(fit_sqrt_Mscore))


# density plot of residuals
```

```
par(mfrow=c(2, 2))
plot(density(resid(fit_sqrt_counting)), main = "Density Counting")
plot(density(resid(fit_sqrt_threshold)), main = "Density Threshold")
plot(density(resid(fit_sqrt_max_corrected)), main = "Density Max
Gripper")
plot(density(resid(fit_sqrt_Mscore)), main = "Density M score")

hist(resid(fit_sqrt_counting))
hist(resid(fit_sqrt_threshold))
hist(resid(fit_sqrt_max_corrected))
hist(resid(fit_sqrt_Mscore))

# K-S test to see whether significantly non-normal residuals (good
when N>50)
library("olsrr")
ols_test_normality(fit_sqrt_counting) # shapiro-wilk is now good for
all tests
ols_test_normality(fit_sqrt_threshold)
ols_test_normality(fit_sqrt_max_corrected)
ols_test_normality(fit_sqrt_Mscore)

#* multicollinearity ####
cor(x = HelmetExp[,c("threshold_sqrt", "counting_interview_sqrt",
"max_corrected_sqrt", "Mscore_sqrt", "previousME")], use =
"complete.obs")
library("corrplot")
```

```
corrplot(cor(x = HelmetExp[,c("threshold_sqrt",
"counting_interview_Sqrt", "max_corrected_sqrt", "Mscore_sqrt",
"previousME")], use = "complete.obs"), method = "number")

#* autocorrelation ####
#Durbin-Watson's d tests for autocorrelation/ independence of
resuiduals
library(lmtest)
dwtest(fit_sqrt_counting ,  alternative = "two.sided")
dwtest(fit_sqrt_threshold ,  alternative = "two.sided")
dwtest(fit_sqrt_max_corrected ,  alternative = "two.sided")
dwtest(fit_sqrt_Mscore ,  alternative = "two.sided")
#no autocorrelation, as 1.5 < d <2.5

plot((resid(fit_sqrt_counting)))
plot((resid(fit_sqrt_threshold)))
plot((resid(fit_sqrt_max_corrected)))
plot((resid(fit_sqrt_Mscore)))


#### Confindence intervals and plots ####

confint(fit_sqrt_counting, parm = 'previousME', level = 0.95)
confint(fit_sqrt_threshold, parm = 'previousME', level = 0.95)
confint(fit_sqrt_max_corrected, parm = 'previousME', level = 0.95)
confint(fit_sqrt_Mscore, parm = 'previousME', level = 0.95)

# Plot CI lines
```

```
library(ggplot2)

ggplot(fit_sqrt_counting, aes(x=previousME,
y=counting_interview_sqrt)) +
  geom_point(color='#2980B9', size = 1) +
  geom_smooth(method=lm, color='#2C3E50') +
  ylab("Counting_squared") +
  xlab ("Previous ME")

ggplot(fit_sqrt_threshold, aes(x=previousME, y=threshold_sqrt)) +
  geom_point(color='#2980B9', size = 1) +
  geom_smooth(method=lm, color='#2C3E50') +
  ylab("Threshold_squared") +
  xlab ("Previous ME")

ggplot(fit_sqrt_max_corrected, aes(x=previousME,
y=max_corrected_sqrt)) +
  geom_point(color='#2980B9', size = 1) +
  geom_smooth(method=lm, color='#2C3E50') +
  ylab("Strength") +
  xlab ("Previous ME")

ggplot(fit_sqrt_Mscore, aes(x=previousME, y=Mscore_sqrt)) +
  geom_point(color='#2980B9', size = 1) +
  geom_smooth(method=lm, color='#2C3E50') +
  ylab("M-scale Score") +
  xlab ("Previous ME")
```

Permutation Analysis

```
#### Permutation analysis ####

##### Load ranks #####

library(readxl)


load("newdata_exp")


rank1 <- newdata_exp[,18:27] #Select columns with Ranking 1 (before
the helmet session)

rank1 <- cbind(rank1, newdata_exp$ppnr) #Add column with participant
numbers

rank2 <- newdata_exp[,40:50] #Select columns with Ranking 2 (after
the helmet session)


#Exclude participants who didn't fill in rank2 (left lab or no
previous Mystical Experiences)

rank2_new <- rank2[-which(is.na(rank2$`Ranking 2- godhelm_1`)),]

rank1_new <- rank1[-which(is.na(rank2$`Ranking 2- godhelm_1`)),]



##### Normalise ranks #####


n <- length(unlist(rank2_new[,1])) #calculate N for Ranking 2

all_helmetrank_norm <- NULL


for (i in 1:n){
```

```
  #for each participant, get length of rank list (= how many
previous Mystical Experiences)
  pp <- rank2_new[i,]

  if (sum(is.na(pp)) == 0){
    total <- length(pp)
  } else {
    total <- length(pp[-which(is.na(pp))])
  }
  #then, select rank position of God helmet
  helmet_rank <- as.numeric(pp[1])

  #Calculate normalized rank
  rank_norm <- helmet_rank / total

  #Make one variable with all normalized ranks
  all_helmetrank_norm <- append(all_helmetrank_norm, rank_norm)
  }


##### Inspect ranking positions #####

# Create one variable with all ranking information
rank1_new$rankpos <- all_helmetrank_norm #add normalized ranking to
rank 1 list

for (i in 1:length(rank2_new[1,])){       #Make rank2 numeric
  rank2_new[,i] <-as.numeric(rank2_new[,i])
```

```
}

full_ranks <- cbind(rank2_new, rank1_new) #add rank 1 and 2 to same
table
colnames(full_ranks)[23] <- "ppnr"

save(full_ranks, file = "full_ranks")

## First place ##
rankfirst <- full_ranks[which(full_ranks$`Ranking 2- godhelm_1` ==
1),]
length(rankfirst[,1]) #1st place = 6
write.csv2(rankfirst, file = "rankfirst.csv")

## Last place ##
ranklast <- full_ranks[which(full_ranks$rankpos == 1),]
length(ranklast[,1]) #38 last place
write.csv2(ranklast, file = "ranklast.csv")

## In the middle ##
rankmiddle <- full_ranks[-which(full_ranks$`Ranking 2- godhelm_1` ==
1),]
rankmiddle <- rankmiddle[-which(rankmiddle$rankpos == 1),]
length(rankmiddle[,1]) #30 last place
write.csv2(rankmiddle, file = "rankmiddle.csv")



##### Permutation: Shuffle ranks #####
```

```
# Calculate mean rank
mean_helmetrank <- mean(all_helmetrank_norm)

# Shuffle ranks for each participant and calculate new mean rank
# Repeat this 10.000 times
mean_perm <- NULL
set.seed(1234)

for (i in 1:10000){
  perm_helmetrank_norm <- NULL
  for (i in 1:n){
    #for each participant, get length of rank list (= how many
previous Mystical Experiences)
    pp <- rank2_new[i,]

    if (sum(is.na(pp)) == 0){
      total <- length(pp)
    } else {
      total <- length(pp[-which(is.na(pp))])
    }

    # Get new randomized helmet rank with sample(1:length)
    perm_helmet <- sample(1:total)[1] # Get first element out of
randomized rank

    rank_norm <- perm_helmet / total # Get normalized random helmet
rank
```

```
    perm_helmetrank_norm <- append(perm_helmetrank_norm, rank_norm)
#add to variable with all mean ranks for this specific permutation
  }

    mean_perm <- append(mean_perm, mean(perm_helmetrank_norm)) #add
to variable with all mean ranks for all permutations
}

# Make a histogram with the mean helmet rank for all permutations
hist(mean_perm, ylim = c(0, 3000), xlim = c(0.45, 0.8), breaks = 10,
xlab = "Mean Rank", main= "Permutation Means", col = 4)
# Add a line to the histogram showing where the original mean helmet
rank lies
abline(v = mean_helmetrank, col = "red")

# See whether the sample's mean helmet rank is above or below 0.5 to
decide on what side of the distribution to test
mean_helmetrank

# Calculate p-value
2*(sum(mean_perm>mean_helmetrank)/length(mean_perm)) # Look at upper
side of distribution


#### Permutation 2: Do analysis again excluding participants with
only 2 previous mystical experiences ####
```

```
#exclude participants who didn't fill in rank2 (left lab or no
previous mystical expeirences)
rank2_exploratory <- rank2[-which(is.na(rank2$`Ranking 2-
godhelm_1`)),]

#exclude participants with only 1 or 2 previous MEs
rank2_exploratory <- rank2[-which(is.na(rank1$`Ranking 1 fill_3`)),]
#interestingly they all have at least 4 previous MEs with this
selection
#(no participants who had only 3 and not 4 pME)

n <- length(unlist(rank2_exploratory[,1])) #N = 58

##### Normalise ranks #####

all_helmetrank_norm <- NULL

for (i in 1:n){
  pp <- rank2_exploratory[i,]

  if (sum(is.na(pp)) == 0){ #if there are no NAs, count
    total <- length(pp)
  } else {
    total <- length(pp[-which(is.na(pp))]) #exclude NAs and count
  }

  helmet_rank <- as.numeric(pp[1])
```

```
  rank_norm <- helmet_rank / total

  all_helmetrank_norm <- append(all_helmetrank_norm, rank_norm)
}

all_helmetrank_norm # 1 = last place

hist(all_helmetrank_norm, breaks = 10) # mostly last place

##### Inspect ranking positions #####
View(table(all_helmetrank_norm))

## 1st place ##
length(which(all_helmetrank_norm <= 0.5)) #16, but not all 1st
place:
# 1st place = 0.5, 0.333, 0.25, 0.2, 0.1666, 0.14, 0.125, 0.111,
0.1, 0.0909
# not 1st place = 0.285 ( = 2/7 x1), 0.3636 ( = 4/11 x1), 0.375 (=
3/8 x1), 0.4 (=2/5 x1)
# 16-4 = 12 rank 1st place

## middle ##
length(which(0.5 < all_helmetrank_norm & all_helmetrank_norm < 1))
#16 + 4 = 20 in between

## last place ##
length(which(all_helmetrank_norm == 1)) #26 last place
```

```
##### Shuffle #####

# calculate mean rank
mean_helmetrank <- mean(all_helmetrank_norm)

#shuffle ranks for each participant and calculate new mean rank
#repeat this 10.000 times


mean_perm <- NULL

set.seed(1234)

for (i in 1:10000){
  perm_helmetrank_norm <- NULL
  for (i in 1:n){

    pp <- rank2_exploratory[i,] # get ranking of one participant

    # get length of ranking without Na's
    if (sum(is.na(pp)) == 0){
      total <- length(pp)
    } else {
      total <- length(pp[-which(is.na(pp))]) #exclude NAs and count
    }

    # get new helmet rank with sample(1:length)
```

```
    perm_helmet <- sample(1:total)[1] # get first element out of
permutation, new helmet rank

    rank_norm <- perm_helmet / total

    perm_helmetrank_norm <- append(perm_helmetrank_norm, rank_norm)
  }
  print(mean(perm_helmetrank_norm))
  mean_perm <- append(mean_perm, mean(perm_helmetrank_norm))
}

save(mean_perm, file = "mean_perm_exploratory") #save permutation

load(file = "mean_perm_exploratory") #load permutation (only if it
has been saved before to save time)

hist(mean_perm, ylim = c(0, 3000), xlim = c(0.45, 0.8), breaks = 10,
     xlab = "Mean Rank", main= "Permutation Means", col = 4)
abline(v = mean_helmetrank, col = "red")

# See whether the sample's mean helmet rank is above or below 0.5 to
decide on what side of the distribution to test
mean_helmetrank

# p-value:
2*(sum(mean_perm>mean_helmetrank)/length(mean_perm)) # p < 0.001 (p
= 0)
```

```
#### Extra analysis: Check influence of social desirability ####
# load variables and packages
load("full_ranks")
load("social_des")
library("dplyr")

# change participant number column to character variable
full_ranks$ppnr <- as.character(full_ranks$ppnr)

# join variables based on their participant number
perm_social <- inner_join(full_ranks, social_des, by = "ppnr")

# calculate correlation
cor(x = as.numeric(perm_social$rankpos), y =
perm_social$SocialScore, use = "complete.obs")
cor.test(x = as.numeric(perm_social$rankpos), y =
perm_social$SocialScore, use = "complete.obs")

#Pearsons r = 0.15, p = 0.2
```

One-sample Median Tests

```
#### One-sample median tests/ Sign tests ####
#### Load variables ####
load("Final_HelmetExp")

HelmetExp$prev_comp <- as.numeric(HelmetExp$prev_comp)
```

```
HelmetExp$day_comp  <- as.numeric(HelmetExp$day_comp)
HelmetExp$day_strong <- as.numeric(HelmetExp$day_strong)

#### OPTIONAL: Exclude friends who participated ####
Friends <- c("R_1dbtpcb96xO0Cn9", "R_3nSEAMGVXy5I9z0",
"R_3m4Awhxa4S49X6n",
  "R_rcjwZlGmmk5XZsZ", "R_1H2CtpAswc1PvaG", "R_3RsAjzTMgbRKf4k",
"R_egnIx5wwOh4jNYt",   "R_1GUMlmid4PcKeTs", "R_1rcfeFwFVq4GA1P")
Friends_select <- NULL

for (i in 1:length(Friends)){
  Friends_select[i] <- which(HelmetExp$ppnr == Friends[i])
  }

HelmetExp <- HelmetExp[-(Friends_select),]

#### Descriptive Statistics ####
# Descriptive statistics for the three variables
describe(HelmetExp[c("prev_comp", "day_comp", "day_strong")])

# Make bar plots for the three variables
pME_plot<- table(HelmetExp$prev_comp)
barplot(pME_plot,  col = c(4) , main = "Were the experiences similar
to previous mystical experiences?",       ylim = c(0, 30), xlab =
"Answer given", ylab = "Frequency")

daycomp_plot<- table(HelmetExp$day_comp)
```

```
barplot(daycomp_plot,  col = c(4) , main = "Were the experiences
similar to daydreaming or imagination?",       ylim = c(0, 35), xlab
= "Answer given", ylab = "Frequency")

daystr_plot<- table(HelmetExp$day_strong)
barplot(daystr_plot,  col = c(4) , main = "How strong or intense
were the experiences compared to daydreaming?” ",         ylim =
c(0, 45), xlab = "Answer given", ylab = "Frequency")


#### Sign test comparing Helmet Experience to previous mystical
experiences ###
# Looks at whether the median of the sample is higher than 3 (that
is, 4 or 5) in the question “On a scale from 1-5, how much do you
think the experiences are comparable?”

x = length(which(HelmetExp$prev_comp > 3))     # x = number of
successes = s
n_na <- length(which(is.na(HelmetExp$prev_comp))) # calculate
missings to exclude later
n = length(HelmetExp$prev_comp) - n_na    # This variation does not
remove ties when calculating n
binom.test(x = x, n = n, p = 0.5, alternative = "greater",
conf.level = 0.95)

#chi square test gives almost exactly same results
prop.test(x = x, n = n, p = 0.5, alternative = 'greater')
```

```
#### Sign test comparing Helmet Experience to daydreaming and
imagination ####
# Looks at whether the median of the sample is lower than 4 (that
is, 1, 2 or 3) in the question "Think of yourself daydreaming, for
example when you get lost in thoughts or you are lost in
imagination. Were the experiences with the helmet similar to that?"

x = length(which(HelmetExp$day_comp < 4))
n_na <- length(which(is.na(HelmetExp$day_comp)))
n = length(HelmetExp$day_comp) - n_na  # Again, no ties removed
binom.test(x = x, n = n, p = 0.5, alternative = "greater",
conf.level = 0.95)

#### Sign test comparing Helmet Experience as stronger than
daydreaming ####
# Tests whether the median of the sample is higher than 3 (that is,
4 or 5) in the question "How strong or intense was the experience
with the helmet compared to daydreaming?"

x = length(which(HelmetExp$day_strong > 3))
n_na <- length(which(is.na(HelmetExp$day_strong)))
n = length(HelmetExp$day_strong) - n_na -
length(which(HelmetExp$day_strong == 3)) # Here I do remove ties
binom.test(x = x, n = n, p = 0.5, alternative = "greater",
conf.level = 0.95)
```

Follow-up exploratory analysis

```
setwd("C:/Users/Irene/OneDrive/Psychologie/CN research
master/Thesis/Analysis statistics/Data")

load("Final_HelmetExp_sq_highpass1")
load("newdata_exp")
# Exclude R_3HN571iZf9taXi9 and load number of previous ME + Mscale
into HelmetExp
HelmetExp$previousME <- newdata_exp$previousME[-80]
HelmetExp$Mscore <- newdata_exp$Mscore[-80]

#### Follow-up 1 month ####
library(readr)
library("dplyr")
Followup1m <- read_csv2("Followup1m.csv") #load data
Followup1m <- Followup1m[-c(1,2),] #remove first two rows

### Clean up sheet ###

# Check how many unique participant numbers (i.e. ExternalReference)
are in the data
length(unique(Followup1m$ExternalReference))
# 2 missing entries, but they don't miss ppnr variable or
flourishing scale.
# double entries for R_3nDIyhscN0cZ0iq, R_2VEdofpejeV1ddU,
R_3KrrvhKfrcXBTwt, R_UauGNQLZSAvNRfz and R_yOU3ZAPrSYJJRfj

# Check which of the double entries should be deleted
```

```
#view(Followup1m[which(Followup1m$ExternalReference ==
c("R_3nDIyhscN0cZ0iq")), ]) #2nd not finished
which(Followup1m$ExternalReference == c("R_3nDIyhscN0cZ0iq"))
#uncompleted is row 73
#view(Followup1m[which(Followup1m$ExternalReference ==
c("R_2VEdofpejeV1ddU")), ]) #2nd also not finished
which(Followup1m$ExternalReference == c("R_2VEdofpejeV1ddU"))
#uncompleted is row 74
#view(Followup1m[which(Followup1m$ExternalReference ==
c("R_3KrrvhKfrcXBTwt")), ]) #also 2nd not finished
which(Followup1m$ExternalReference == c("R_3KrrvhKfrcXBTwt")) #2nd
one is row 72
#view(Followup1m[which(Followup1m$ExternalReference ==
c("R_UauGNQLZSAvNRfz")), ]) #also 2nd not finished
which(Followup1m$ExternalReference == c("R_UauGNQLZSAvNRfz")) #2nd
one is row 76
#view(Followup1m[which(Followup1m$ExternalReference ==
c("R_yOU3ZAPrSYJJRfj")), ]) #also 2nd not finished
which(Followup1m$ExternalReference == c("R_yOU3ZAPrSYJJRfj")) #2nd
one is row 75

# Check which entries are missing
which(is.na(Followup1m$ppnr)) #none

Followup1m <- Followup1m[-c(72,73,74,75,76),] #remove doubles and no
participant number

missing_followup1m <- HelmetExp$ppnr %in% Followup1m$ppnr * 1
```

```
HelmetExp$ppnr[which(missing_followup1m == 0)] # missing follow-up
1m for 6 participants: #"R_UiEvhfT6KZtQ4hP" "R_2tkYy57aTiN0g5R"
"R_2rOeazRcIhg8P69" "R_2y3CNqOmWfOrGLQ" "R_3luESDJoNsG32c7"
"R_1GUMlmid4PcKeTs"

### Load flourishing scale ###
Flourishing1m <- as.data.frame(sapply(Followup1m[,29:36],
as.numeric))

Flourishing1m$FlourishingScore1m <- unlist(rowSums(Flourishing1m)) #
calculate score for each participant
Flourishing1m$ppnr <- Followup1m$ExternalReference # add participant
number row

# Add Flourishing scale to data frame with all the data
HelmetExp_Flourishing <- inner_join(HelmetExp, Flourishing1m, by =
"ppnr")

### Load Flourishing scale at baseline ###
load("Screening2_clean")
FlourishingBaseline <- as.data.frame(sapply(newdata_sc[,86:93],
as.numeric))

FlourishingBaseline$FlourishingBaseline <-
unlist(rowSums(FlourishingBaseline)) # calculate score for each
participant
FlourishingBaseline$ppnr <- newdata_sc$ppnr # add participant number
row
```

```
# Add Flourishing scale to data frame with all the data
HelmetExp_Flourishing <- inner_join(HelmetExp_Flourishing,
FlourishingBaseline, by = "ppnr")

# Calculate difference score between Flourishing at baseline and at
1-month follow-up
HelmetExp_Flourishing$FlourishingDiff <-
HelmetExp_Flourishing$FlourishingScore1m -
HelmetExp_Flourishing$FlourishingBaseline



#### Follow-up 1 day ####
Followup1d <- read_csv("Followup1d.csv") #load data
Followup1d <- Followup1d[-c(1,2),] #remove first two rows

### Clean up sheet ###

# Check how many unique participant numbers (i.e. ExternalReference)
are in the data
length(unique(Followup1d$ExternalReference)) ==
length(Followup1d$ExternalReference)
# all unique

missing_Followup1d <- HelmetExp$ppnr %in%
Followup1d$ExternalReference * 1
HelmetExp$ppnr[which(missing_Followup1d == 0)] # missing follow-up
1m for 25 participants
```

```
### Load flourishing scale ###
Flourishing1d <- as.data.frame(sapply(Followup1d[,29:36],
as.numeric))

Flourishing1d$FlourishingScore1d <- unlist(rowSums(Flourishing1d)) #
calculate score for each participant
Flourishing1d$ppnr <- Followup1d$ExternalReference # add participant
number row

# Add Flourishing scale to data frame with all the data
HelmetExp_Flourishing <- inner_join(HelmetExp_Flourishing,
Flourishing1d, by = "ppnr")

#### Follow-up 1 week ####
Followup1w <- read_csv("Followup1w.csv") #load data
Followup1w <- Followup1w[-c(1,2),] #remove first two rows

### Clean up sheet ###

# Check how many unique participant numbers (i.e. ExternalReference)
are in the data
length(unique(Followup1w$ExternalReference)) ==
length(Followup1w$ExternalReference)
# doubles
length(unique(Followup1w$ExternalReference)) #2 entries are double
Followup1w$ExternalReference[duplicated(Followup1w$ExternalReference
)] #just NA's are double
```

```
Followup1w$ppnr[which(is.na((Followup1w$ExternalReference)))]
# NAs for "2y3CNqOmWfOrGLQ"   "R_3HN571iZf9taXj9" "R_2w4tKWBw0g6Z9"
, but flourishing is there

missing_Followup1w <- HelmetExp$ppnr %in%
Followup1w$ExternalReference * 1
HelmetExp$ppnr[which(missing_Followup1w == 0)] # missing follow-up
1m for 20 participants

### Load flourishing scale ###
Flourishing1w <- as.data.frame(sapply(Followup1w[,29:36],
as.numeric))

Flourishing1w$FlourishingScore1w <- unlist(rowSums(Flourishing1w)) #
calculate score for each participant
Flourishing1w$ppnr <- Followup1w$ExternalReference # add participant
number row

# Add Flourishing 1w scale to data frame with all the data
HelmetExp_Flourishing <- inner_join(HelmetExp_Flourishing,
Flourishing1w, by = "ppnr")
#this only shows participants who have scores for all variables

#### Descriptives ####
describe(FlourishingBaseline$FlourishingBaseline)
describe(Flourishing1d$FlourishingScore1d)
describe(Flourishing1w$FlourishingScore1w)
describe(Flourishing1m$FlourishingScore1m)
```

```
#### Correlation Flourishing with measures in lab session ####
#load variables in multvariate regression file

hist(HelmetExp_Flourishing$FlourishingDiff)



library("Hmisc")
rcorr(x = as.matrix(HelmetExp_Flourishing[,c("counting_interview",
"threshold", "max_corrected", "Mscore", "FlourishingBaseline",
"FlourishingScore1m" , "FlourishingDiff")]))

plot(HelmetExp_Flourishing$max_corrected,
HelmetExp_Flourishing$threshold)

### Flourishing and M-scale regression ####
# Does the M-scale score predict difference in Flourishing scores
after 1 month?
describe(HelmetExp_Flourishing$FlourishingScore1m)

sum(is.na(HelmetExp_Flourishing$FlourishingScore1m)) #one
participant with NAs

fit_Flourishing <- lm(FlourishingScore1m ~ FlourishingBaseline +
Mscore + FlourishingBaseline:Mscore, data = HelmetExp_Flourishing,
na.action = na.omit)
```

```
plot(fit_Flourishing)

summary(fit_Flourishing)

# Look at data
plot(HelmetExp_Flourishing$FlourishingScore1m)
hist(HelmetExp_Flourishing$FlourishingScore1m, breaks = 10)

plot(HelmetExp_Flourishing$FlourishingBaseline)
hist(HelmetExp_Flourishing$FlourishingBaseline, breaks = 10)

# Assumptions
plot(HelmetExp_Flourishing$Mscore,
HelmetExp_Flourishing$FlourishingBaseline)
plot(HelmetExp_Flourishing$Mscore,
HelmetExp_Flourishing$FlourishingScore1m)
library(olsrr)
ols_test_normality(fit_Flourishing) # Non-significant SW and K-S.
All good.

qqnorm(resid(fit_Flourishing), main = "Flourishing-Mscore Q-Q Plot")
qqline(resid(fit_Flourishing))

# Density plot of residuals
plot(density(resid(fit_Flourishing)), main = "Density Flourishing-
Mscore") # A bit skewed to right
hist(resid(fit_Flourishing))
```

```
### Flourishing and M-scale regression ####
# Does the M-scale score predict difference in Flourishing scores
after 1 month?
describe(HelmetExp_Flourishing$FlourishingScore1m)

sum(is.na(HelmetExp_Flourishing$FlourishingScore1m)) #one
participant with NAs

fit_Flourishing <- lm(FlourishingScore1m ~ FlourishingBaseline +
Mscore + FlourishingBaseline:Mscore, data = HelmetExp_Flourishing,
na.action = na.omit)

plot(fit_Flourishing)

summary(fit_Flourishing)

# Look at data
plot(HelmetExp_Flourishing$FlourishingScore1m)
hist(HelmetExp_Flourishing$FlourishingScore1m, breaks = 10)

plot(HelmetExp_Flourishing$FlourishingBaseline)
hist(HelmetExp_Flourishing$FlourishingBaseline, breaks = 10)
# Assumptions
plot(HelmetExp_Flourishing$Mscore,
HelmetExp_Flourishing$FlourishingBaseline)
plot(HelmetExp_Flourishing$Mscore,
HelmetExp_Flourishing$FlourishingScore1m)
library(olsrr)
```

```
ols_test_normality(fit_Flourishing) # Non-significant SW and K-S.
All good.

qqnorm(resid(fit_Flourishing), main = "Flourishing-Mscore Q-Q Plot")
qqline(resid(fit_Flourishing))

# Density plot of residuals
plot(density(resid(fit_Flourishing)), main = "Density Flourishing-
Mscore") # A bit skewed to right
hist(resid(fit_Flourishing))



#### Check why correlation table is different from regression
results ####
  # Multicollinearity ####
# can be inflated because of interaction term, so do with model
without interaction
# Perform a multiple regression analysis without the interaction
term
fit_Flourishing_noint <- lm(FlourishingScore1m ~ FlourishingBaseline
+ Mscore, data = HelmetExp_Flourishing, na.action = na.omit)

# Calculate VIF values
vif_values <- vif(fit_Flourishing_noint)
print(vif_values)

# Calculate tolerance values
tolerance <- 1 / vif_values
```

```
print(tolerance)


#### Partial correlations ####
library(ppcor)
pcor((HelmetExp_Flourishing[, c("FlourishingBaseline", "Mscore",
"FlourishingScore1m")]))
pcor(x = HelmetExp_Flourishing[,c("threshold", "counting_interview",
"max_gripper_scaled", "Mscore", "previousME", "FlourishingBaseline",
"FlourishingScore1m")])
# doesnt work because of missings


partial.r(data = HelmetExp_Flourishing, x = c("Mscore",
"FlourishingScore1m"), y = "FlourishingBaseline")


#### Plot interaction terms to see how Mscore and Flourishing One
Month change at different levels of Flourishing Baseline.####
# Create a scatterplot with the interaction effect
ggplot(HelmetExp_Flourishing, aes(x = Mscore, y =
FlourishingScore1m, color = FlourishingBaseline)) +
  geom_point() +
  geom_smooth(method = "lm", se = FALSE) +
  labs(title = "Interaction Effect Flourishing Baseline:Mscore")



#### Median split ####
# Create a new variable for median split
```

```
HelmetExp_Flourishing$FlourishingBaseline_median <-
ifelse(HelmetExp_Flourishing$FlourishingBaseline <
median(HelmetExp_Flourishing$FlourishingBaseline), "Low", "High")

# Run regression with median split variable
fit_Flourishing_median <- lm(FlourishingScore1m ~ Mscore +
FlourishingBaseline_median + Mscore:FlourishingBaseline_median, data
= HelmetExp_Flourishing)

# Examine coefficients and significance
summary(fit_Flourishing_median)

# Create scatterplot
plot(HelmetExp_Flourishing$Mscore,
HelmetExp_Flourishing$FlourishingScore1m,
     main = "Scatterplot with Median Split Regression",
     xlab = "Mscore", ylab = "FlourishingScore1m")

# Add median split lines
abline(v =
median(HelmetExp_Flourishing$Mscore[HelmetExp_Flourishing$Flourishin
gBaseline_median == "Low"]), col = "red")
abline(v =
median(HelmetExp_Flourishing$Mscore[HelmetExp_Flourishing$Flourishin
gBaseline_median == "High"]), col = "blue")

# Add regression line
abline(fit_Flourishing_median, col = "green")
```

```
# Add legend
legend("bottomright", legend = c("Low Flourishing Baseline Median",
"High Flourishing BaselineMedian", "Regression Line"),
       col = c("red", "blue", "green"), lty = 1, cex = 0.5)

# same with ggplot to add colour dots. Shows regression lines.
ggplot(data = HelmetExp_Flourishing, aes(x = Mscore, y =
FlourishingScore1m, color = FlourishingBaseline_median)) +
  geom_point() +
  scale_color_manual(values = c("red", "blue")) +
  geom_smooth(method = "lm", se = FALSE) +
  labs(title = "Scatterplot of FlourishingScore1m vs. Mscore", x =
"Mscore", y = "FlourishingScore1m")




#### Manipulation check ####
table(Followup1m$`stimulation yesno`) # 1 = yes, 2 = no
table(Followup1m$`deceived yesno`)

ManipulationCheck <- as.data.frame(sapply(Followup1m[,c(48, 50,
52)], as.numeric))

ManipulationCheck <- cbind(ManipulationCheck, Followup1m[,13])
```

```
names(ManipulationCheck)[4] <- "ppnr"

# Add manipulation check to data frame with all the data
HelmetExp_manipulation <- inner_join(HelmetExp, ManipulationCheck,
by = "ppnr")

#decriptives Mscore for each believers vs sceptics

Mscore_stimulation <- HelmetExp_manipulation %>%
  group_by(`stimulation yesno`) %>%
  summarise(
    mean_Mscore = mean(Mscore),
    median_Mscore = median(Mscore),
    min_Mscore = min(Mscore),
    max_Mscore = max(Mscore),
    sd_Mscore = sd(Mscore),
    n = n()
  )

#descriptives button presses for believers vs sceptics

Counting_stimulation <- HelmetExp_manipulation %>%
  group_by(`stimulation yesno`) %>%
  summarise(
    mean_counting = mean(counting_interview),
    median_counting = median(counting_interview),
    min_counting = min(counting_interview),
    max_counting = max(counting_interview),
```

```
    sd_counting = sd(counting_interview),
    n = n()
  )

Threshold_stimulation <- HelmetExp_manipulation %>%
  group_by(`stimulation yesno`) %>%
  summarise(
    mean_threshold = mean(threshold, na.rm = T),
    median_threshold = median(threshold, na.rm = T),
    min_threshold = min(threshold, na.rm = T),
    max_threshold = max(threshold, na.rm = T),
    sd_threshold = sd(threshold, na.rm = T),
    n = n()
  )


# Button press strength #
Strength_stimulation <- HelmetExp_manipulation %>%
  group_by(`stimulation yesno`) %>%
  summarise(
    mean_strength = mean(max_corrected, na.rm = T),
    median_strength = median(max_corrected, na.rm = T),
    min_strength = min(max_corrected, na.rm = T),
    max_strength = max(max_corrected, na.rm = T),
    sd_strength = sd(max_corrected, na.rm = T),
    n = n()
  )
```