BRIEF REPORT

Metarepresentations of Supernatural Belief and the Effect of Context on Cognitions

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HIGHLIGHTS

There is a difference between what people subconsciously 'believe' and what they publicly claim to believe. New evidence suggests that these subconscious beliefs can markedly influence how a person thinks.

ABSTRACT

This study aimed to see if context in the form of priming can alter a participant's thinking style based on their level of implicit association with either a religious or paranormal belief. This was based on the theory of alief, when a person's explicit belief and behavior are mismatched. This was also linked to dual process theory, with alief being analogous to type one thinking styles (fast and automatic). One hundred and seventy-two participants were recruited from the University of Derby and social media. Implicit association was measured using a modified Brief Implicit Association Test that looked at paranormal and religious belief. Explicit supernatural belief, cognitive reflection, metacognition, and confidence also were measured. A hierarchical multiple regression revealed that a lower belief in the supernatural (apart from psychokinesis), a religious prime, and high confidence predicted reflective thinking. Common paranormal perceptions, religious prime, and confidence were significant predictors in the model. It was concluded that the prime worked on a moral level and influenced someone with an already open mind to different beliefs to be more analytical, positive, and confident. This study does not support the theory of alief; however, it indicates certain beliefs are susceptible to a certain prime, and that a person can be influenced to be more analytical.

INTRODUCTION

The link between supernatural belief and intuitive thinking has been demonstrated in many studies (Schofield et al., 2020); however, the findings of these studies have been mixed. Some researchers have linked these mixed findings to different types of belief (such as religious or paranormal) having different thinking styles (Schofield et al., 2020). These studies generally measure explicit belief, what a person *says* they believe, rather than a measure of implicit belief, what a person *actually* believes. A priming paradigm, avoiding conscious intention, could be used to demonstrate whether these potential implicit beliefs have an impact on cognition. Priming effects have been examined for both religiosity (e.g., Bloom & Arikan, 2013; Shariff

et al., 2008), and paranormality (Nees & Phillips, 2015; Pizzagalli et al., 2000). Bloom and Arikan (2013) demonstrated that priming can trigger specific types of implicit belief. Shariff et al. (2015) concluded that priming does not affect non-religious participants reliably and it might depend on a different style of activation for this group, indicating that a cognitive prime could be used to elicit a belief within a particular context. However, analytic thinking does increase religious disbelief (Gervais & Norenzayan, 2012). In addition, Nees and Phillips (2015) used priming in a paranormal context when looking at Electric Voice Phenomena (EVP) and found a clear indication that priming and context affect perception within a paranormal framework. Measuring explicit belief, implicit belief, and examining the effect a prime has on thinking style for different types of belief,

alongside metacognition (thinking about thinking), to measure how a person monitors their own thought processes, will provide a model of how what we believe can affect the way we think in certain situations. The nature of implicit belief is potentially tricky to conceptualize; one way this has been done, is to draw a distinction between explicit belief and the more implicit 'alief'.

The category of 'alief' arose from a belief vs. behaviour mismatch and the perceived discrepancy between explicit belief and behaviour (Gendler, 2008b). Alief is an intuitive reaction to a given situation that is based on a particular cognitive state. This state can be activated by either internal or external stimuli. The example that Gendler (2008b) uses is a person who is afraid to walk across a glass-bottomed bridge over a canyon, or a person who gets scared by a horror film, even though they know they are in no danger. These are however arguably rational fears for safety; it is not unreasonable to be afraid of falling from a great height. The repetitive behaviors that an OCD sufferer may engage in are also proposed to be an 'alief'; the repetitive actions not being 'believed' to really prevent a bad thing from happening. This could also be linked to negative metacognition (Zawidzki, 2019) or worrisome thoughts, and cause a problem when belief and alief do not match (Gendler, 2008a). Regarding religious and paranormal beliefs, some of the discrepancies in the research could be due to 'aliefs', particularly if intuitive dualists are implicitly attracted to certain beliefs (Bloom, 2009; Hood et al., 2012). This distinction between belief and alief has also been studied in terms of a Type One (intuitive) and Type Two (reflective) dual process framework (Kriegel, 2012).

According to dual process theory, Type One processing is intuitive, automatic, unconscious, and implicit. Type Two is reflective, flexible, wide-ranging, and explicit, and therefore controllable (Kahneman, 2011). Kriegel (2012) considers the mental state of alief and belief to be analogous to the two states within Dual Process Theory. Alief is analogous to Type One and belief is analogous to Type Two. However, previously it is beliefs themselves that are driving Type One thinking. This could go part way to explaining the mixed findings surrounding thinking styles and different types of belief, and ultimately help to establish the direct influence between belief and cognition (Schofield et al, 2020). Alief could be part of the intuitive system and influence it, but not totally separate from belief, as alief is just one aspect of belief. This provides a starting point and a way to conceptualize alief and belief; seeing them as dichotomous may not be helpful, and Gendler (2008b) does state that alief is a precursor to belief development. While the connection between alief and belief and dual process might seem attractive (almost intuitively so), caution should be taken when creating a bifurcation of mental states for convenience

sake. That said, implicit attitudes have been studied in the past and Gendler (2011) refers to the Implicit Association Test as being a possible measure of alief.

Previous studies researching implicit belief focused on the paranormal (Stieger & Hergovich, 2013), the religious (Bassett et al., 2005), the supernatural and skepticism (Lindeman & Svedholm-Häkkinen, 2016), or the relationship between religious and paranormal (Weeks et al., 2008). Stieger and Hergovich (2013) showed that there is no correlation between implicit paranormal belief (measured using an implicit association test) and explicit paranormal belief, indicating that this is a valid area of enquiry. Lindeman and Svedholm-Häkkinen (2016) found that skeptics were not affected by a manipulation in the context of religious belief, but skeptics who were not analytic thinkers could be open to biases toward supernatural belief given the right conditions. This study questions the assumption that everyone has implicit supernatural belief; however, skeptics in the appropriate conditions can be primed using religious stimuli. This demonstrates that even though skeptics may explicitly disbelieve in religion, they can be primed to react to it. This could be seen as an implicit belief or an alief. The relationship between implicit and explicit attitudes has been seen to be affected by metacognition (Cooley et al., 2015), therefore it is not unreasonable to suggest that implicit and explicit belief could also be affected by metacognition.

Metacognition is how a person monitors their own thoughts and is often referred to as 'thinking about thinking' (Flavell, 1979), and has been studied alongside dual process theory, in relation to confidence and monitoring cognition (Mata et al., 2013). Baker and Morrison (1998) found that maladaptive metacognitions like worrisome thoughts were related to higher levels of paranormal belief. Elements of metacognition are correlated with paranormal beliefs, for example, Cognitive Self-Consciousness and Uncontrollability and Danger, but only for women (Irwin et al., 2012). However, while direct studies linking metacognitions and paranormal belief are sparse, they have been studied in areas alongside paranormal belief, for example, superstition (Cartwright-Hatton & Wells, 1997), psychoticism (Reeder et al., 2010), and schizotypy (Stirling et al., 2007). However, there is a dearth of studies relating directly to religiosity and metacognition. It has been posited that metacognitions can be used to train alief (Zawidzki, 2019), indicating that those with good metacognitive skills should be able to control their aliefs more, and therefore not be prone to priming. Those who exhibit negative metacognitions should be more prone to priming and their explicit and implicit beliefs should not match.

A measure of metacognition would provide the link

between implicit and priming paradigms and provide further evidence surrounding different types of belief and how they affect cognition. There is evidence that belief has an effect on reasoning and thinking style, however the measure of the belief could be having an effect. Dual process theory appears to link to belief strongly, but the role of implicit belief or alief is unclear. A priming paradigm could offer insight into the mechanism behind this process and metacognition would also show the awareness of a particular holder of belief of their perceived limitations.

Hypotheses

It is hypothesised that negative priming, negative belief, negative metacognitions, positive confidence, and negative implicit belief, will predict a reflective thinking style.

METHODS

Participants

This study recruited participants (n = 172) via social media, and from students and staff at the University of Derby using opportunity sampling. Ages of the participants ranged from 18 to 67 (mean = 28.34, SD = 10.19). The gender of the participants was 48 (27.9 %) male, 121 (70.3 %) female, 2 preferred to self-describe (1.2%), and one (0.6 %) preferred not to answer. Participants' self-identified religious belief included: Muslim, Hindu, Christian, atheist, none, and Jewish. One hundred and fifty-seven identified as students. Three hundred and sixty-one people attempted the survey with 172 completing it, giving a completion rate of 47.65%. Ethics were obtained through the University of Derby Human Sciences Research Ethics Committee, reference number 07-1718-MSp.

Instruments/Measures

An online survey (Qualtrics) was used to host the study.
Initial Condition Manipulation. Priming was carried out in the following way: There were three different contexts: religious, paranormal, and neutral. The context was manipulated by asking the participant to rank 10 statements. The religious prime group were asked to 'Please read the following Ten Commandments and rank them in terms of their importance to you'. These included: 'You shall have no other gods before me' and 'You shall not make for yourself an idol.' The paranormal prime group were asked to 'Please read the following paranormal statements and rank them in terms of how much you think they are likely to exist'. The statements included: 'Some individuals are able to levitate (lift) objects through mental forces' and 'Black magic really exists'. Finally, the neutral prime group were

asked to 'Please rank these statements from the most too the least believable'. These statements included: '"Rhythm" is the longest English word without a vowel' and 'There is a city called Rome on every continent'.

The measures used in this study were as follows: 'Belief in the Supernatural Scale' (Schofield et al., 2018) to measure belief, MCQ 30 (Wells & Cartwright-Hatton, 2004) to measure negative metacognition, Cognitive Reflection Test–Long (Primi et al., 2015) to measure thinking style, and the Brief Implicit Association Test (Sriram & Greenwald, 2009) to measure implicit association.

Belief in the Supernatural Scale (BitSS). The BitSS (Schofield et al., 2018) has 44 items with five subscales. These are: 'mental and psychic phenomena' (16 items), 'religious belief' (10 items), 'psychokinesis' (4 items), 'supernatural entities' (7 items) and 'common paranormal perceptions' (7 items). The scores range from 44 and 308 and is scored using a seven-point Likert scale (strongly disagree to strongly agree). One item (39) is reversed. Items include: 'There are individuals who are messengers of God', 'There is both a spiritual as well as a natural side to reality' and 'Some individuals are able to levitate (lift) objects through mental forces. The scale demonstrates excellent validity and reliability (α = .97) (Schofield et al., 2018).

Metacognition Questionnaire 30 (MCQ-30). Metacognition was measured using the MCQ-30 (Wells & Cartwright-Hatton, 2004), a 30-item questionnaire. The MCQ-30 measures a range of Metacognitive Domains. The subscales being: Cognitive Confidence; Positive Beliefs; Cognitive Self-Consciousness; Uncontrollability and Danger; and the Need to Control Thoughts. Each of these subscales has 5 items. A Likert Scale is used to measure the levels from 1 (do not agree) to 4 (agree very much); a minimum score of 30 and a maximum score of 120 can be scored by adding the response to each item. Statements on the questionnaire include: 'My worrying is dangerous for me'; 'I monitor my thoughts'; and 'I have a poor memory'. Calculating subscales is achieved by adding the subscale scores and dividing by the number of items in that subscale. The Cronbach's Alpha Scores to calculate reliability for the full scale are: α = .93 showing good to excellent internal reliability and good convergent validity are also noted.

Cognitive Reflection Test–Long (CRT-L). The CRT-L (Primi et al., 2015) has 6 items that measure effortful reasoning. The items can be classified in three ways: correct answers, an intuitive (heuristic) incorrect response, or a response that was neither correct nor intuitive. The response format is a four-option multiple choice; a correct answer, an incorrect 'heuristic' answer, and two incorrect answers. Example items include: 'A bat and a ball cost £1.10 in total. The bat costs £1.00 more than the ball. How much does the ball cost?' (Correct answer = 5 p; heuristic answer = 10 p),

'In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?' (Correct answer = 47 days; heuristic answer = 24 days). For this study, the scores were calculated so a higher score indicates reflective thinking.

Confidence Scale for CRT-L. Confidence in each answer given for the CRT-L was measured using the question 'How confident are you that you gave the correct answer? Please adjust the slider below to between 0 (totally not sure) and 100 (totally sure)' (De Neys et al., 2011). The participant could then use a slider on the survey tool to select the appropriate number.

Brief Implicit Association Test (BIAT). Due to the exploratory nature of the use of the measure, the BIAT (Sriram & Greenwald, 2009) was opted for over the more lengthy IAT (Greenwald et al., 1998). Unlike the IAT, the BIAT focuses on 2 out of the 4 categories (religious, paranormal, positive, and negative). This will enable the measuring of implicit association between the religious and the paranormal. The test was split into blocks of trials, and within these tasks participants are asked to press a specific key when shown a particular combination of stimuli; for example, 'press the left key when the paranormal word is combined with a good word'. These stimuli are in 4 categories (religious, paranormal, positive, and negative), and each category has 4 items. The words used are as follows: Religious: God, Religion, Worship, Sacred; Paranormal: Paranormal, Psychic, Haunting, Poltergeist; Positive: Wonderful, Best, Superb, Excellent; Negative: Terrible, Awful, Worst, and Horrible. The test was run as follows: The first 2 blocks are practice blocks and the remaining 4 blocks of trials are experimental and recorded. Within the blocks, there are 12 trials in the practice block and 20 trials in the experimental block as per (Sriram & Greenwald, 2009). Item, trial, and block numbers are based on previous research. Scoring the BIAT is based on the D measure (Greenwald et al., 2003) which give each participant a score ranging from –2 to +2. A positive score indicates an implicit religious preference and a negative one a paranormal implicit preference. There are other methods of scoring the task, however, this is seen to be the most effective (Greenwald et al., 2003). If error rates exceeded 20%, the cases will be excluded (Greenwald & Farnham, 2000).

Procedure

After participants were recruited, they were emailed details of the study and a link to the online survey that was hosted at www.qualtrics.com and were then briefed on details of the study and presented with the rights to withdraw, anonymity, and confidentiality. They were asked if they agreed and wanted to participate. They were then asked to create a unique ID code. Demographic data was then taken: age, gender, religious belief, occupation, and education. Each participant was placed in one of three different context groups, religious, paranormal, or neutral that acted as the priming conditions. This context was reflected in the brief. The participant also completed a task relating to the context that acted as a prime. Participants were then presented with the scales in a randomized order, and the BIAT. After the study, participants were debriefed.

RESULTS

Descriptive Statistics

Descriptive statistics were examined to determine the normality of distribution of the data, initially for all the scores (see Table 1).

The data were examined for normality by eyeballing histograms and boxplots, z skewness and z kurtosis, and finally z scores for outliers. Histograms indicated possible skewness and kurtosis in BIAT, supernatural entities, psychokinesis, religious belief, and confidence, and identified possible outliers in BIAT, metacognition, psychokinesis, and confidence. Z skewness and z kurtosis were examined within the priming groups for cases that lay outside of –2.58 to +2.58 (samples sizes between 100 and 200) (Field, 2013). Confidence appeared skewed (–6.45), as did psychokinesis (5.38), and religious belief (3.65). Kurtosis was present in the variables confidence (3.73), reflective thinking (–2.75), supernatural entities (–3.09), and common paranormal perceptions (–2.89). Z scores indicated confidence (–3.79), psychokinesis (3.23), metacognition (3.09), and BIAT (–3.09) scores being slightly out of range of the threshold of –3 to 3 (–3.23 being the lowest), but confidence being the only variable of concern with 3 participants below –3 (–3.02 to –3.79). While skewness and kurtosis were present in some variables and outliers were detected, the issues were minor and deemed to be within the assumptions of the test, meeting univariate normality (Field, 2013).

Main Analysis. Hierarchical multiple regression was used to examine if the BitSS subscales, negative metacognitions, confidence, and the BIAT were good significant predictors of reflective thinking. Variance inflation factor (VIF) values (largest = 4.51) indicated multicollinearity was not an issue, although the Durbin-Watson value (2.05) indicated no issue regarding correlation of adjacent residuals. Cook's Distances < 1, indicating no problems with outliers.

The predictors were entered in the following order, the block included the subscales from the BitSS and the three priming group manipulations. This was dummy-coded due to there being three groups of categorical data of neutral (n = 60), paranormal (n = 57), and religious (n = 55), with the neutral group being used as a

TABLE 1. Correlations, Mean, and SDs of the BitSS (and Subscales), Confidence, CRTL (Reflective), Negative Metacognition, and the BIAT

	Reflective Thinking	BitSS Total	Mental and Psychic Phenomena	Religious Belief	Psychokinesis	Supernatural Entities	Common Paranormal Perceptions	Confidence	Metacognition	BIAT
BitSS Total	**−0.274									
Mental and Psychic Phenomena	**-0.306	**0.902								
Religious Belief	-0.024	**0.686	**0.364							
Psychokinesis	**−0.201	**0.754	**0.721	**0.337						
Supernatural Entities	**-0.211	**0.892	**0.69	**0.739	**0.534					
Common Paranormal Perceptions	**−0.396	**0.744	**0.782	*0.145	**0.709	**0.546				
Confidence	**0.248	0.034	-0.057	**0.226	0.038	0.045	*−0.144			
Metacognition	0.011	−0.066	−0.006	*−0.172	−0.001	−0.117	0.09	−0.003		
BIAT	*0.143	−0.116	**−0.199	*0.161	**−0.228	−0.034	**−0.288	**0.208	*−0.159	
Mean	2.436	142.494	3.692	2.88	2.241	3.519	3.003	76.983	65.401	0.312
SD	1.676	56.44	1.544	1.753	1.397	1.73	1.366	18.492	15.738	0.44

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

baseline measure in Model One; with both the religious and paranormal being entered as separate variables and coded as 1 (0 being coded for the rest). This method is in line with the approach recommended by Hayes (2018). The dummy coding method to handle multi-categorical antecedents also has been seen to be effective for issues surrounding multicollinearity and model fit (Eze Francis et al., 2018). The three following blocks were entered separately, as follows: first confidence in Model Two, then metacognition in Model Three, and finally implicit association in Model Four. The second block indicated a significant change to the F value (p = .019), and the final two blocks did not indicate a significant change to the F value (p = .464 and p = .893). Thus, Model Two appears to account for the maximum variance in predicting reflective thinking. The regression model using the subscales from the BitSS, the

three priming groups of neutral, paranormal, and religious with the neutral group being used as a baseline measure, and confidence to predict reflective thinking was significant (F(8, 163) = 5.803, p < .001), with 22% of the variance in the outcome being explained by the predictors (R^2 = .222, adjusted R^2 = .183). For full details of all the models, see Table 2.

There were significant positive relationships between religious prime (β = .157, p = .049) and confidence (β = .174, p = .019), and reflective thinking. And a significant negative relationship between common paranormal perceptions and reflective thinking (β = −.409, p = .002). There were no significant relationships between mental and psychic phenomena (β = −.057, p = .677), religious belief (β = −.004, p = .974), psychokinesis (β = .133, p = .237), supernatural entities (β = −.022, p = .882), and the paranormal prime (β = .102, p = .208).

TABLE 2. Model Progressions for the Regressions

	β	t	p	R	R^2	Adjusted R^2	F change	Sig F Change
Model One				0.441	0.195	0.16	5.664	<0.001
Mental and Psychic Phenomena	−0.066	−0.474	0.636					
Religious Belief	0.052	0.429	0.668					
Psychokinesis	0.166	1.474	0.142					
Supernatural Entities	−0.047	−0.319	0.75					
Common Paranormal Perceptions	−0.446	−3.384	0.001					
Paranormal Prime	0.113	1.386	0.168					
Religious Prime	0.172	2.136	0.034					
Model Two				0.471	0.222	0.183	5.651	0.019
Mental and Psychic Phenomena	−0.057	−0.417	0.677					
Religious Belief	−0.004	−0.033	0.974					
Psychokinesis	0.133	1.186	0.237					
Supernatural Entities	−0.022	−0.149	0.882					
Common Paranormal Perceptions	−0.409	−3.128	0.002					
Paranormal Prime	0.102	1.263	0.208					
Religious Prime	0.157	1.98	0.049					
Confidence	0.174	2.377	0.019					
Model Three				0.474	0.224	0.181	0.54	0.464
Mental and Psychic Phenomena	−0.058	−0.423	0.673					
Religious Belief	0.001	0.004	0.997					
Psychokinesis	0.138	1.226	0.222					
Supernatural Entities	−0.014	−0.095	0.925					
Common Paranormal Perceptions	−0.423	−3.197	0.002					
Paranormal Prime	0.11	1.35	0.179					
Religious Prime	0.158	1.984	0.049					
Confidence	0.171	2.323	0.021					
Negative Metacognition	0.053	0.735	0.464					
Model Four				0.474	0.224	0.176	0.018	0.893
Mental and Psychic Phenomena	−0.058	−0.419	0.676					
Religious Belief	−0.002	−0.015	0.988					
Psychokinesis	0.14	1.229	0.221					
Supernatural Entities	−0.013	−0.091	0.927					
Common Paranormal Perceptions	−0.422	−3.169	0.002					
Paranormal Prime	0.109	1.33	0.185					
Religious Prime	0.158	1.973	0.05					
Confidence	0.169	2.271	0.024					
Negative Metacognition	0.054	0.743	0.459					
Implicit Association	0.01	0.135	0.893					

DISCUSSION

The findings of the study indicated the model that explained the most variance included the subscales of the BitSS, the priming condition and confidence, significantly predicting reflective thinking style. Metacognition and implicit association added little and were not included in the final model. The significant predictors were as follows: common paranormal perceptions negatively, religious prime positively, and confidence positively predicted reflective thinking. The non-significant predictors were in the following directions: mental and psychic phenomena negatively, religious belief negatively, psychokinesis positively, supernatural entities negatively, and the paranormal prime positively. Overall, this showed partial support for the hypotheses.

The model predicted that a lower belief in the supernatural (apart from psychokinesis), a priming of an 'alief,' and high confidence predicts reflective thinking. The supernatural prime had an effect; however, it was only the religious prime, and not the paranormal, partially supporting previous research that examined religious (Bloom & Arikan, 2013; Shariff et al., 2008) and paranormal primes (Nees & Phillips, 2015; Pizzagalli et al., 2000). Whether or not this activated an implicit belief remains to be seen, but the results of this study do not support this, showing no effect in the model of implicit association. The religious prime did have an effect and according to this model the activation was in people who did not believe in common paranormal phenomena. The religious prime had an effect on thinking style, but this was not in the direction predicted. This finding conflicts with previous research showing that reflective thinking can affect belief, with analytic thinking increasing religious disbelief (Gervais & Norenzayan, 2012).

This further indicates that when the prime is tried in the other direction, it has a different effect, with the religious prime increasing analytic thinking. Furthermore, only the religious prime was a significant predictor. Supernatural belief also had an effect on thinking style, again in line with previous research (Pennycook et al., 2012), and this time in the direction predicted, apart from psychokinesis, which positively predicted reflective thinking. But only common paranormal perception was a significant predictor, and as with previous research this was a negative predictor of reflective thinking. Negative metacognitions and implicit association did not add anything to the model, although they did positively correlate (toward implicit religious belief) for metacognition, this goes against previous research that associated it with thinking style (Mata et al., 2013), but this finding could be a consequence of using a scale that measures negative metacognitions. Taken together, essentially, the model indicates that a religious prime, a lack of belief in common paranormal perceptions, and being confident, predict a reflective thinking style.

The significance of the religious prime seems to indicate that it has activated an alief, providing support for this theory, but if the analogy between type one (aleif) and type two (belief) thinking (Kriegel, 2012) holds, then the prime should have negatively predicted reflective thinking. However, this was not the case. Furthermore, it should be noted at this point that due to the correlational nature of the study, it cannot be claimed that the prime activated the alief and only that the prime is correlated with the thinking style. Taking this one step further, it would appear that if you did not believe in common paranormal perceptions and were confident, along with the prime, that this would predict a reflective thinking style. Rather than offer support for alief, this does indicate that the religious prime isn't priming an underlying alief; it is priming something else. Furthermore, the lack of significance of both implicit association and metacognition further diminishes support for alief. Correlations do indicate that elements of implicit association and metacognition have a relationship with belief, implicit association (toward implicit religious belief) positively correlating with religious belief, indicating there was no implicit/explicit mismatch. Also, negative metacognitions positively correlated with religious belief, indicating possible intrusive thoughts. This warrants further exploration.

One issue could be the nature of the prime. The religious prime could have been more of a moral prime. The rule-based nature of the prime may also have been a confound with rule-based primes being successful in prompting analytic thinking. This could account for the use of the Ten Commandments being successful. Also, the metacognition measure focused on negative metacognitions; therefore, an alternate measure of general metacognition is needed. This research leveraged standard statistical approaches grounded in Classical Test Theory. However, some authorities have strongly urged the use of Modern Test Theory (MTT) methods for improved measurement and model-building, especially as the assessment of paranormal belief and subjective experiences is inherently prone to response biases and other psychometric pitfalls (e.g., Lange, 2017; Lange et al., 2019). Thus, future research might re-examine the independent and dependent variables considered here using MTT frameworks. Additionally, it could be useful to test the relational patterns revealed by our regression analyses with more advanced modeling techniques that can sometimes account for attenuated results from measurement error (e.g., path analysis or structural equation modeling). We also refer readers to Laythe et al.'s (2021, pp. 142–143) summary of even more advanced options rooted in machine learning. Also, the use of dummy coding

in this way collapses the scatterplot into two box plot-like distributions, where the line of best fit is the slope created by the difference between the two groups. This means it only functionally mimics an ANOVA means test. Therefore, using categorical variables as predictors should be treated with caution.

Conclusion

This study indicated that primes do have an effect on certain types of belief. However, the extent to which this influences cognition needs further investigation. The primes themselves need more scrutiny to make sure it is the implicit belief that is being primed rather than a moral code being primed. While the nature of implicit belief is still unclear, belief does have an influence on thinking style. If this relationship can be reversed, and a type of implicit belief can be elicited by a prime of a certain thinking style remains to be seen. This study does not support the theory of alief; however, it indicates certain beliefs are susceptible to a certain prime, and that a person can be influenced to be more reflective.

IMPLICATIONS AND APPLICATIONS

This study implies that priming influences cognition. Furthermore, this could mean that primes could impact other beliefs. It would also be interesting to see if these findings can inform the study of paranormal or religious experiences and if priming is linked to experience and belief and to investigate the nature of this relationship. It would be interesting to see if priming can be used for beliefs such as conspiracy beliefs. Particularly appropriate given the current antivax and COVID situation. These methods could be instrumental in the fight against misinformation, disinformation, and so-called 'fake news'. While the alief question remains unanswered, more work in this area is needed to identify if there is a process occurring at an implicit level.

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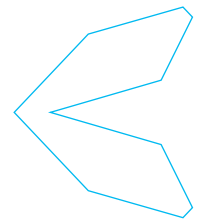
ESSAY

Corona Discharges on von Reichenbach's Terrellae?

Marinus Anthony van der Sluijs

HIGHLIGHTS

Light formations unlike known polar aurora phenomena were reported during classic experiments with a miniature model that simulated the earth's magnetic and electric properties. The nature of these observed anomalies remains intriguing and elusive.

ABSTRACT

In the 1840s, extensive experimentation led von Reichenbach to postulate an "Odic force" associated with "Odic light" or "magnet light," of which the polar aurora would be an example in space. The physical nature of the visible phenomena reported by his assistants during the experiments has never been satisfactorily identified. It is argued that "Od" compares to plasma or ionised gas, while at least a subset of the investigations, conducted on terrellae, represented the first experimental work on corona discharges. Accordingly, the glows on the terrellae cannot be directly compared to the aurora.

OD

The German baron Carl Ludwig von Reichenbach (1788–1869) was an eccentric naturalist, geologist, chemist, metallurgist, philosopher, and industrialist who embarked on an extensive study of disorders of the human nervous system upon his retirement from industry. Taking certain people diagnosed as "sensitives" into a completely dark room with magnets, magnetic devices, or crystals and allowing them ample time to adjust to the lack of light, he relied on their testimony in his theory of "a peculiar force in nature, which spans the whole universe . . . different from all hitherto known forces, here designated by the word 'Od'" (von Reichenbach, 1849a, p. 210; 1851, p. 221).[1] Fancifully named after the native Scandinavian god Odin (von Reichenbach, 1852, p. 198; 1860, p. 84), this "Odic force" was supposed to be tied to but nevertheless distinct from magnetism and electricity. It would manifest in "Od light," in five formal categories: glow-like, flame-like, thread-, fibre-, and fluff-like, smoke-like, and spark-like (von Reichenbach, 1849b, p. 53, cf. 435–436; 1851, p. 270, cf. 223).[2]

Von Reichenbach earned his reputation as an oddball even in his own lifetime primarily by his understanding

Carl Ludwig von Reichenbach

of Od as a form of "life energy" that produced the radiant wraiths of the newly dead and what some would now call "auras." The concept was similar to the *prāṇa* of Indian and the *qì* of Chinese metaphysics—though with an emphasis on electric and magnetic aspects, not on air and breath. In this respect, it resembled Franz Anton Mesmer's theory of "animal magnetism," which was beginning to fall out of fashion at the time (Alvarado, 2009, pp. 366–368, 375). Od can also be compared to younger vitalistic hypotheses such as Henri Bergson's *élan vital* and Wilhelm Reich's orgone. Quite different from the orthodox repertoire of intellectually acceptable notions at the time, such esoteric connotations, together with the claim that only "sensitives" were capable of perceiving Od, explain why the subject has always remained so odious to scientists.

OD AS PLASMA

The "sorcerer of Cobenzl"—as von Reichenbach was nicknamed, after his castle on the outskirts of Vienna—was far from incompetent or scientifically illiterate, however; he composed unsensational reports more sedulous than credulous. In hindsight, some of his observations on the Odic influence on living organisms prefigure the findings of Robert Otto Becker (1923–2008) and other bioelectromagnetists by more than a century; though many of these were dubious, they were not unscientific in essence. What von Reichenbach called "magnet light" (*Magnetlicht*) was in effect a successor to Edmond Halley's notion of "magnetic effluvia" rendered visible in the polar aurora (Halley, 1716, pp. 421–423; cf. Briggs, 1967, pp. 492–493; Hansteen, 1827, p. 340). Yet whereas Halley had only theorised its existence in analogy to electric glows seen in laboratories, von Reichenbach claimed to have observational evidence for it. Leaving the broader mystery of its physical nature for others to solve, a subset of von Reichenbach's experimentation undertaken in the years 1844–1847 appears to simply represent early unwitting work on self-sustaining gaseous discharges not powered by electrostatic friction. This can be gathered from the inclusion in many of the experiments of an armature or electromagnet and rarefaction by means of an air-pump:

The Odic light appearances of the magnet change under varied air pressure. They gain in strength considerably upon rarefaction of the air (von Reichenbach, 1849b, p. 162 [cf. 159–161, 168, 172, 231–235]; 1851, p. 381 [cf. 378–380, 382, 386, 390, 442–444]).

More beautiful, though, and more distinctly marked was the appearance on *electromagnets*.

Here I was able to . . . heighten the appearances more and make them more clearly perceptible . . . (von Reichenbach, 1849b, p. 175 [cf. 176–178, 212–214, 222–223]; 1851, p. 394 [cf. 395–396, 426–428, 435]).[3]

Because the "magnet light" intensified with vacuum, it was arguably—at least in such cases—a glow or corona discharge produced before scientists comprehended that electric discharges can be sustained by direct current (DC). In the 1830s, the English scientist Michael Faraday (1791–1867) had revived the study of glow discharges and, inspired by Ørsted and Ampère, laid much of the groundwork for that of electromagnetism, proving the fundamental identity of static electricity, Voltaic electricity or electric current, electricity induced by a magnet, and animal electricity (Faraday, 1833; 1839, pp. 76–109). However, for years this work had failed to ignite interest (Hiebert, 1995, pp. 95–97). The faintness of the glows reported by von Reichenbach's volunteers must variously have been due to weakness of the electric component, wavelengths at the boundary of the visible spectrum, or a low degree of vacuum—close to normal air.[4]

O'Byrne (1926, pp. 110–117), a translator of von Reichenbach's work, cited visible discharges between a cathode and an anode in a vacuum tube as a method that might bring the effects of Odic force within the ken of "non-sensitives," but he insisted that Od, the electrified matter, had to be something different from electricity alone. The electron, electrical conductivity by ions, and ionisation of matter remained unknown during von Reichenbach's lifetime. Glow and corona discharges are electrical discharges that feature a visible plasma, that is, a visible partly ionised gas. "Od" though it may sound, von Reichenbach's imponderable force may actually be a state of matter that equates to plasma—equally unknown at the time, with the single exception of the "radiant matter" hypothesised by Faraday in 1816 (Jones, 1870, pp. 195–196, 268–270; cf. van der Sluijs, 2019, pp. 87–88; 2011, p. 663). Despite his Mesmerist proclivities and mystifying vocabulary, von Reichenbach would, accordingly, qualify as a respectable pioneer of plasma physics—and of plasma cosmology.

VON REICHENBACH'S WORK ON TERRELLAE

Von Reichenbach (1849b, pp. 234–239; 1851, pp. 445–448) postulated that the earth's magnetic field is generated by iron diffused through the earth's interior but is continually modified by "accessions" from the sun and moon. Specifically, he believed the iron to subsist in a cool, crystallised state, emitting Odic light that caused

the magnetisation. Like Halley before him, he regarded the northern and southern lights, or aurorae, as visible outflow of the earth's magnetic field.

One series of experiments aimed at deciphering the riddle of the aurorae involved terrellae "after the manner of Barlow" (von Reichenbach, 1852, p. 172; 1860, p. 76; cf. 1849b, p. 217; 1851, p. 431), which the Maverick referred to by the French "terrelles" (von Reichenbach, 1849b, pp. 210–224, 234–240; 1851, pp. 425–437, 444–449).[5] A terrella ("little earth" or "earthlet") is a miniature model of the earth, mostly used to simulate the earth's magnetic and electric properties. Von Reichenbach worked in succession with two smooth hollow globes of sheet iron, each composed of two hemispheres tightly fitted together, which he suspended by a silken cord passing through a hole in the joint between the halves. Inside each sphere he placed an electromagnet in the form of an iron bar wound with silk-covered copper wire. This was positioned upright inside the terrella, its ends being in immediate contact with the sphere. The two extremities of the wire were connected to an external Voltaic zinc-and-silver battery through two little holes in the sphere (von Reichenbach, 1849b, pp. 211, 218; 1851, pp. 425, 431).

Several light formations purportedly seen on these terrellae, in all categories of "Odic light," are worth singling out. An all-encompassing shell of light around the first terrella constituted one type of formation. One attendant, Sophie Pauer *née* Streicher (1791–1861), beheld "a delicate grey misty gauze spread all over the ball's surface, which she discerned most distinctly in profile and which rose above the ball's surface to a height of a centimetre" (von Reichenbach, 1849b, p. 213; 1851, p. 427). Von Reichenbach (1849b, p. 217; 1851, p. 431; cf. 1852, p. 172; 1860, p. 75) called this "*a luminous vapour shell*, a kind of delicate *photosphere*, which surrounds it," consisting of "an opaque veil of light, which does not rest on the globe's surface, but is located at a little distance from it, and floats freely in the air above its surface, like a spherical shell." A second distinct structure, showing again on the first terrella, was a radiant girdle around the equator. Sophie Pauer described this as "a more luminous, narrow and whitish-yellow ring laid all around the equator" (1849b, p. 213; 1851, p. 427). Another viewer, Cæcilie Bauer (born circa 1819), reported that "the equator itself formed a narrow, somewhat lightened band all round the globe" (1849b, p. 213; 1851, p. 428). Josephine Zinkel (born circa 1822), too, "perceived the belt that followed the equator around the globe," "a luminous streak, which follows the greatest circumference horizontally around and thus divides the globe into two halves, in an upper and a lower one," which is to be "understood like a fine comb with countless very short teeth, which sit up at right angles and point to the poles" (1849b, p. 214; 1851, p. 428).

Finally, perhaps the most significant morphology is that of vertical filamented beams above the poles. "Above the globe, as well as below it," witness Josephine Fenzl saw "lights as thick as an arm streaming out of the polar points, which then, according to her own expression, spread like open parasols over the globe, concentric with it, both above and below, but at a little distance from it" (1849b, p. 212; 1851, p. 426). Josephine Zinkel had it that the light emerging from the poles "formed towards the equator a great star, with apparently innumerable points, or rather thread-like radiant prolongations, which ran down the globe in colours . . ." (1849b, p. 214; 1851, p. 428). She "likened the whole Od-flame to a loosely-bound sheaf of grain, which, standing upright on the ground, bent over its ears and stalks in curves on all sides, so that they lay apart horizontally upon one another over the bundle" (1849b, p. 217; 1851, p. 430). Other descriptions she used were "an overhanging wheat-sheaf" and "a tassel turned the wrong way upwards" (1849b, p. 219; 1851, p. 432). According to Cæcilie Bauer, the continuous "luminosity of the globe over its surface" resolved itself into

> innumerable clearly distinguishable filaments, which to her seemed . . . about one millimetre thick (knitting needle, she said), and ran from the blue patch of the upper pole and the red one of the lower perpendicularly towards the girdle . . . She described these filaments as not so much independent isolated streaks, as rather merely lines of greater intensity of light, alternating with lines of lower intensity of light, so as to give a streaked appearance to the whole as if nothing but threads ran down from the poles. They were all of the colour corresponding to the point of the compass toward which they were directed . . . (1849b, p. 214; 1851, p. 428)

This woman, too, used the simile of a star, noticing how the coloured patches at the poles "became subdivided, and graded into the filaments which ran downwards over the succeeding zones; this gave the polar patches a star-like appearance;" "apparent projections and hollows developed and so formed a kind of star shape to the eye" (1849b, p. 215; 1851, p. 429).

At a later time, when the second, much larger terrella was taken into use, observer Marie von Augustin *née* Regelsberg von Thurnberg (1807–1886) noticed

> at both poles short luminous columns flowing out as a kind of vapour, reddish at the positive pole and blue at the negative one . . . These columns or stalks of light, as she called them, spread out

at the top and turned over. She compared them with the image afforded by a palm-tree, where the leaves, directed at right angles to the stem, stretch out and diverge on all sides. (1849b, p. 218; 1851, p. 432)

Wilhelmine Glaser (born circa 1821), a different witness on the same occasion, resorted to the metaphor of a tree as well, as she "perceived the entire globe to be streaked in colours, from top to bottom":

The coloured streaks were about of a hand's breadth where they passed over the equator, and were separated from each other by an opaque, indistinct, transitional streak of the same breadth, in which the colours were blended together. She saw a mass of blue light above, which she also described as resembling a tree of which the stem ascended from the pole and which lowered its branches away from each other, overhanging on all sides. (1849b, pp. 218–219; 1851, p. 432)

Another visitor, Anka Hetmanek (born circa 1824), again "saw streams of light issuing above and below from the globe; that is, from both poles, which spread out on all sides in the manner of a tree" (1849b, p. 219; 1851, p. 432). The baron concluded with respect to these "coloured meridians" running "from pole to pole":

. . . now for the Od-flame. One such flowed out from each pole, perpendicularly to the surface of the globe, 5 to 6 centimetres in height and 3 to 4 centimetres thick, but then *it expanded on top and on all sides bent down parallel to the globe's surface*, broke up and frayed, and at once flowed out parallel into the air in filaments of Od-flame . . . The streaks of this Od-flame did not remain at rest, but flickered and scintillated constantly backwards and forwards, shortened and lengthened, shot out radiantly . . . *flaming lights exist over the poles of the magnet . . .* this *flaming appearance appears mobile, undulating, frequently serpentine, like rolls of riband blown about by the wind*; often enlarging and shrinking itself, then shooting out rays, scintillating, variegated, also *vaporous . . .* (von Reichenbach, 1849b, pp. 218, 217, 232; 1851, pp. 432, 430, 443)

On top at the place where the north-pointing pole of the electromagnet was located, a column of light tending towards the blue rose hand-high over the ball, then bent over in all directions,

like an opened umbrella, and streamed down all around over the ball, at a distance of two to three inches from it. From the other pole, the south-pointing one below, a similar tuft of fire ascended all around over the ball in reddish light. Both frayed and faded out before they reached the ball's equator. (von Reichenbach, 1852, p. 172; 1860, pp. 75–76)

Thus, each of the two iron globes appeared to provide support for the conclusion that "the 'Northern-Lights' are positive od-lights" (1852, p. 173; 1860, p. 76; cf. 1849b, p. 240; 1851, p. 449):

. . . so we recognise in it a kind of *terrelle, which exhibits artificial northern and southern lights in miniature . . . Their poles emit . . . delicate light visible only in the darkness of night. High above both poles it turns over and flows on all sides towards the tropical zones*, broken up in the way of filaments and rays on the great terrestrial globe just as on the little *terrelle . . .* (1849b, p. 234; 1851, p. 444; cf. 1845, pp. 5, 23–26; 1849a, pp. 5, 19–22; 1849b, pp. 210–211, 217, 231–233, 239–240; 1851, pp. 22–23, 39–41, 425, 431, 442–443, 449; 1852, pp. 171–173; 1860, pp. 75–76)

AURORAE OR CORONA DISCHARGES?

The various luminous emanations from von Reichenbach's terrellae were reported with remarkable consistency. From a modern perspective, possible correlates in the geomagnetic dipole field are readily imagined: a fully ionised sphere—or "ionosphere"—around the globe, a ring current around the magnetic equator, and the field lines above the auroral ovals that outline the hollow centre of the toroidal plasmasphere. The fine filamentary structure that the savant's companions observed in the funnels and even the equatorial belt is characteristic of plasma, as is well known from the field-aligned rays in the aurora (e.g., Peratt, 2015, pp. 2, 22, 26, 41, 46). Of the three basic types identified above, von Reichenbach himself associated only the polar funnels with the earth's aurora. In the mid-19th century, the existence of the ionosphere and the equatorial ring current was not yet suspected. Neither these two structures nor the greater parts of the polar funnels—everything above the familiar auroral ovals—are normally seen to glow visibly.

The similarities between von Reichenbach's results and the auroral reality in space are in fact deceptive. For one thing, the actual earth's auroral rings comprise a dayside and a nightside sector formed by different mechanisms. On

the dayside, charged particles from the solar wind flow in directly and without much acceleration through the polar cusps, producing the near-continuous but usually feeble or subvisual daytime aurora as they collide with nitrogen and oxygen atoms residing in the polar upper atmosphere on that side. By contrast, particles diverted along the magnetopause create the more characteristic intermittent aurorae associated with geomagnetic substorms and storms by being accelerated from the central plasma sheet in the magnetotail or the radiation belts towards the nightside of the polar upper atmosphere and colliding with the same types of atoms there, with much more vigour than on the dayside (Simmons, 1998, pp. 247–251, 255–256; Eather, 1980, pp. 218–230; Iijima & Potemra, 1976). Evocative though the structural analogy may be between the polar funnels on von Reichenbach's terrellae and those in real space, it should, therefore, not be pushed too far.

That aside, the glows on these globes were probably of a wholly different character than the true aurorae. The visible aurorae are discharges in glow and arc mode occurring in the highly rarefied air of the upper atmosphere. Von Reichenbach did not use the air-pump in combination with the terrellae, so that the light effects seen over them all must have taken place at atmospheric pressure. Unfortunately, he did not provide a circuit diagram or illustration of the setup in his book, complicating efforts to picture the experiments accurately or replicate them. They do not appear to have involved a pair of electrodes. Taking into account that the Volt unit was only introduced in 1861, it is also unclear what voltage von Reichenbach applied to the apparatus. All these uncertainties notwithstanding, a barely visible direct-current corona discharge ionising the air around a spherical conductive surface might be the correct interpretation of the "Od light" on the terrellae. Corona discharges, also called incomplete discharges, tend to occur at air pressure and focus on sharp points, as in the classic St. Elmo's fire, but can also spread out over a single hemispherical or spherical electrode (Riba et al., 2018; Giao & Jordan, 1968). Due to the weakness of the radiation, they can be descried only in darkness. Moreover, most of the radiation falls within the ultraviolet spectrum (Riba et al., 2018, p. 3). While St. Elmo's fire is easily seen by anyone, the air being ionised enough, corona discharges can usually be detected only by the comparatively few humans who are capable of seeing ultraviolet or near-ultraviolet light or are otherwise equipped with acute vision:

> The corona discharge emits radiation in the 280–405 nanometer (nm) spectral range, mostly in the ultraviolet (UV) range, and therefore is invisible to

the human eye. However, relatively weak emission at about 400 nm might be observed at night under conditions of absolute darkness. (Chan et al., 2008, p. 7-5)

Typically reporting a whitish-violet light, people who can make out this feeble light will have been the type considered "sensitive" by von Reichenbach. Aphakia, which is the condition of lacking a lens, was probably not the cause of their ability to see ultraviolet light, as it is usually associated with impaired vision and old age.

The particular manifestations beheld by the "sensitives" as polar rays read most like the streamer mode and the pulseless glow mode, fixed at one point, of a negative corona discharge; these two stages convert into one another with a change in voltage (Giao & Jordan, 1968, pp. 1208–1209, 1213, 1215; cf. Riba et al., 2018, pp. 4–5) (Figure 1 and Figure 2). The pattern that von Reichenbach called a "photosphere" must be a type of positive corona discharge on a spherical electrode known as Hermstein's glow, "an ionized layer adhering to the electrode surface," which forms "when the density of the negative space charge becomes high enough to completely suppress the onset streamers." (Giao & Jordan, 1968, p. 1209, cf. 1210, Fig. 4, 1210–1212, 1214). The filamentary structures on von Reichenbach's terrellae would have traced the electric field lines followed by ions created in the discharge. This does not preclude the involvement of the magnetic dipole field produced by the electromagnet, by which von Reichenbach meant to simulate the geomagnetic dipole field. According to a recent study, "the effect of the magnetic field" supplied by a permanent magnet on a direct-current corona discharge "increases as the degree of vacuum increases" and "is the most significant with the negative corona discharges rather than with positive corona discharge" (Elabbas, 2014, p. 189, cf. 191–194). This might mean that the magnetic dipole field around von Reichenbach's terrellae was modestly influential on the discharge. The equatorial ring was apparently perpendicular to the junction of the two hemispheres from which each terrella was forged. Hence it could not have been an artefact of the material imperfection along this circumference and was probably the faint spontaneous product of the dipole field.

An electric field of the order of 100 kV/m is typically required to create discharges in air. Corona discharges occur around power lines and in the laboratory when electric potentials of the order of 100 kV are reached. It remains a *desideratum* to know whether or not von Reichenbach possessed equipment capable of generating such voltages or whether any of the experiments perchance took place during conditions conducive to thunderstorms.
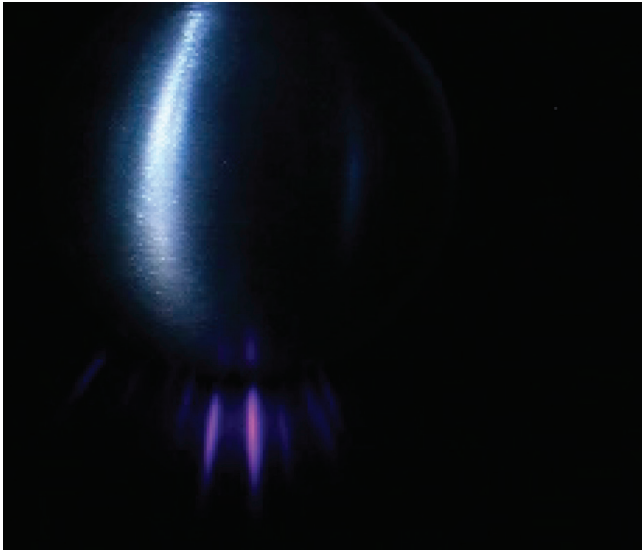
Figure 1. Direct-current corona discharge of negative polarity on a spherical surface, showing a stage with few moving streamers in blue to purple colours (from Riba et al., 2018, p. 10, fig. 4a left).

Figure 2. Direct-current corona discharge of negative polarity on a spherical surface, showing a stage with an amalgam of moving streamers blurring into a broad glow in blue to purple colours (from Riba et al., 2018, p. 10, fig. 4b).

CONCLUSION

In sum, von Reichenbach's *magnum opus* on terrellae could prove to be the earliest known experimental work on corona discharges. It is difficult to be certain on this count, however, as long as some of the specifics of his setup remain unknown, notably the achieved voltages. And did his work foreshadow elements of modern geophysical theory? Absent the aid of a crystal ball to gaze directly into the past, the only way to find out may be to keep the ball rolling on a veritable Od-yssey of unprejudiced research in real and space laboratories alike.

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NOTES

[1] In citations from von Reichenbach's texts, page numbers in the original German edition are given before the numbers in the contemporary English translation. All translations quoted in the text of this article are mine.

[2] The English edition from 1851 translated "Incandescence," "Flame," "Threads, streaks, and nebulæ," "Smoke," and "Sparks."

[3] The armature is mentioned passim.

[4] For recent progress in the production of atmospheric-pressure glow discharges (APGDs), see Wang et al., 2018.

[5] Nahm (2012), in his informative overview of von Reichenbach's dramatic life and work, made no mention of the terrella work or electric discharges.

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