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Misperception of Chance, Conjunction, Framing Effects and Belief in the Paranormal: A Further Evaluation

Summary: Studies exploring relationships between belief in the paranormal and vulnerability to cognitive bias suggests that believers are liable to misperception of chance and conjunction fallacy. Research investigating misperception of chance has produced consistent findings, whilst work on conjunction fallacy is less compelling. Evidence indicates also that framing biases within a paranormal context can increase believers' susceptibility. The present study, using confirmatory factor analysis and structural equation modelling, examined the contribution of each bias to belief in the paranormal and assessed the merits of previous research. Alongside the revised paranormal belief scale, participants completed standard and paranormal framed perception of randomness and conjunction problems. Perception of randomness was more strongly associated with belief in the paranormal than conjunction fallacy. Inherent methodological issues limited the usefulness of framing manipulations; presenting problems within a paranormal context weakened their predictive power.

Key words: Belief in the paranormal; misperception of chance; conjunction fallacy

INTRODUCTION

Several studies report positive associations between probability misjudgement and belief in the paranormal (Blackmore & Troscianko, 1985; Bressan, 2002; Brugger, Landis, & Regard, 1990; Brugger & Taylor, 2003; Dagnall, Drinkwater, Parker, & Rowley, 2014; Dagnall, Parker, & Munley, 2007). Seminally, Blackmore and Troscianko (1985) observed that non-believers (goats) outperformed psi believers (sheep) on tasks requiring judgements of probability. Collectively, findings are consistent with Bressan's (2002) notion that believers in the paranormal possess a lower subjective chance threshold, which inclines them to perceive unrelated events as causally related.

Following a review of previous work, Dagnall et al. (2007) postulated that misrepresentation of chance (poor understanding of coincidence) influenced the development and maintenance of paranormal beliefs. To test this notion, Dagnall et al. (2007) asked participants to complete the Revised Paranormal Belief Scale (Tobacyk, 2004) alongside a range of problem-solving tasks. Tasks assessed four reasoning domains: perception of randomness (judging the likelihood of obtaining strings/sequences), base rate (probability of a stated outcome in relation to base rate information), conjunction fallacy (determining whether co-occurring events were more likely to occur than single, constituent events) and derivation of expected value (evaluating odds in order to maximise pay-outs). As hypothesised, the best predictor of level of paranormal belief was performance on perception of randomness tasks; believers (participants scoring above the median) performed less well on perception of randomness tasks (vs. non-believers). These findings confirmed that belief in the paranormal related specifically to misrepresentation of randomness (rather than a general weakness in probabilistic reasoning). Particularly, the tendency to perceive random events (coincidences) as causally related (meaningful; Brugger & Taylor, 2003).

In addition to misrepresentation of chance, the work of Rogers and colleagues (Rogers, Davis, & Fisk, 2009; Rogers, Fisk, & Wiltshire, 2011) reported that level of paranormal belief was predicted by susceptibility to conjunction fallacy. Whilst this finding is not without contention it merits consideration (see Dagnall et al., 2007). Conjunction fallacy is a specific probabilistic reasoning error involving overestimation of co-occurring events (Tversky & Kahneman, 1983). Within conjunction problems, the likelihood of co-occurrence (P[A&B]) cannot exceed the likelihood of constituent events (P[A] or P[B]) because the possibility set is included within the extension of its constituents (Tversky & Kahneman, 1983). Thus, a conjunction (event co-occurrence) can never be more likely than either constituent part. A classic and well-cited example is the Linda problem. Tversky and Kahneman (1983) asked participants to rate the likelihood of conclusions drawn from a hypothetical personality sketch of a fictitious person (Linda): 'Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.' Participants evaluated propositions about whether Linda was a bank teller, or a bank teller and an active feminist. Tversky and Kahneman (1983) across scenario derivations found that between 50% and 90% of participants demonstrated conjunction error (Brotherton & French, 2014). This indicated that descriptive information contained within the Linda vignette often guided responses, rather than the rules of probability (Hertwig & Chase, 1998).

The work of Rogers and colleagues is centrally important because few studies focus exclusively on the role of conjunction error. Indeed, the paucity of previous work motivated construction of the Scenario Judgements Questionnaire (SJQ) (Rogers et al., 2009). The SJQ contains 16 conjunction vignettes divided into non-paranormal/standard (e.g., queuing for airport coffee) and paranormal (e.g., alleged precognition) events. Using the SJQ, Rogers et al. (2009) reported significant findings: paranormal believers (vs. non-believers) made more conjunction errors, conventional conjunctions produced more errors than paranormal conjunctions, and conjunction error rate did not vary as a function of response format (probability vs frequency). Rogers et al. (2011) conducted a follow-up study. Although, they repeated the finding that believers (vs. non-believers) produced more conjunction errors, they failed to replicate the outcome that conjunction performance varied as a function of problem type (standard vs. paranormal). On this basis, Rogers et al. (2011) concluded that conjunction bias represented a general rather than a domain specific bias.

Noting the inconsistent nature of conjunction findings, Dagnall et al. (2014) investigated further the degree to which specific probabilistic biases (perception of randomness, base rate, conjunction fallacy and probability) were associated with belief in the paranormal and proneness to reality testing deficits. Consistent with Rogers et al. (2009, 2011), both standard and paranormal conjunctions were included. To ensure results were not an artefact of the paranormal measure used the study employed three independent measures of paranormal belief (Manchester Metropolitan University-New, Dagnall, Parker, Munley, & Drinkwater, 2010a, 2010b; Revised Paranormal Belief Scale, Tobacyk & Milford, 1983; and Australian Sheep–Goat Scale, Thalbourne & Delin, 1993). Regression analysis confirmed that perception of randomness was the best predictor of belief in the paranormal and proneness to reality testing deficits (Inventory of Personality Organization-Reality Testing; Lenzenweger, Clarkin, Kernberg, & Foelsch, 2001). Performance on standard conjunctions correlated only with the Tradition Paranormal Belief dimension of the Revised Paranormal Belief Scale. There was no evidence to support Rogers et al. (2009, 2011) assertion that general propensity to conjunction was associated with belief in the paranormal. There was however, a framing effect. Performance on paranormal conjunctions correlated negatively with paranormal belief (increased belief was associated with decreased problem solving accuracy) and proneness to reality testing deficits. This result supported Rogers et al. (2009) and contradicted Rogers et al. (2011).

Recently, Brotherton and French (2014) conducted a related study investigating the relationship between belief in conspiracy theories and susceptibility to conjunction fallacy. Brotherton and French (2014) found, regardless of contextual framing, that participants high in conspiracism (vs. low) produced more conjunction errors. On this basis, they determined that belief in conspiracies was associated with a domain-general susceptibility to conjunction fallacy. Brotherton and French (2014) found moderate positive correlations between conspiratorial beliefs and conjunction, but observed only weak relationships between paranormal belief and conjunction types (neutral, paranormal, conspiracy and overall). Only concurrent median split analysis indicated that believers (vs. non-believers) were more prone to conjunction error. Based on this outcome, Brotherton and French (2014) deduced that their study represented a qualified replication of Rogers et al.’s (2009, 2011) findings. Considering the weak observed correlations and frequently cited criticisms of variable dichotomization (MacCallum, Zhang, Preacher, & Rucker, 2002) this appears a bold claim.

Evaluating Rogers et al.’s findings, Dagnall et al. (2014) concluded that there was no compelling evidence to support the notion that conjunction fallacy was a major factor associated with the development and maintenance of paranormal beliefs. More plausibly and consistent with the extant evidence is the possibility that believers susceptibility to conjunction error arises from their proneness to misperception of randomness (Tversky & Kahneman, 1974, 1982, 1983). Accordingly, the relationship between conjunction and belief in the paranormal is potentially attributable to the fact that conjunction is a specific instance of misperception of chance. Thus, conjunction error in the context of paranormal belief acts as an indirect index of misperception of chance. This supposition is consistent with Charness, Karni, and Levin’s (2008) observation that conjunction error is prevalent in situations in which intuitive heuristics (e.g., *representativeness* and *availability*) mediate likelihood judgments. Thus, the degree to which misperception of chance and conjunction are independently related to belief in the paranormal was examined within the present study.

The present study

Although, previous research reports positive correlations between belief in the paranormal and probability misjudgement, the relative importance of specific biases (misrepresentation of chance and conjunction fallacy) remains undetermined. This stems mainly from a lack of theoretical clarity and methodological coherence. Biases are not easily delineated or classified. Within the academic literature, there are various taxonomies, which hint at relationships but fail to provide definitive solutions. For instance, the general heuristic taxonomy proposed by Tversky and Kahneman (1974) is historically important, yet theoretically dubious; the taxonomy's reliance on a limited number of general heuristics results in classification problems. Hence, there is a lack of bias specification. Experimental biases appear often within more than one of the heuristics (representativeness, availability, anchoring and adjustment), whereas others are not included within the taxonomy.

An effective taxonomy should consolidate knowledge, illuminate relationships between different aspects of decision-making, and be consistent with research (Arnott, 1998, 2006). The classification system must also gain general acceptance and be regarded as internally consistent. Noting, these premises and the inadequacy of previous taxonomies, Arnott (1998) proposed a classification system. The taxonomy draws upon perceived similarities/differences between biases, which provide discrete groupings and provide a framework for subsequent research. Identification begins at the highest level of classification (memory, statistical, confidence, adjustment, presentation and situation) and then considers the degree to which specific biases effect classification. In the context of the present paper, statistical biases are germane. This category subsumes both chance (mistaking random events for essential process characteristics; Wagenaar, 1988) and conjunction (the overestimation of probability in compound problems; Tversky & Kahneman, 1983). To date few papers have considered the association between these biases in relation to paranormal belief. The notion that misperception of chance and conjunction can be located within a mutual category explains potentially their respective relationships to belief in the paranormal.

Arnott's (1998, 2006) classification system provides a structure for conceptualising and comprehending previous findings. Particularly, within the present paper it enabled the prediction of precise relationships between biases and belief in the paranormal. The hierarchical structure of statistical bias indicated that misperception of chance would be the best predictor of belief in the paranormal. It predicted also, that any observed relationship between conjunction and belief would be largely attributable to common membership of the statistical bias category. Thus, the authors proposed that proneness to conjunction fallacy represented a specific manifestation of misrepresentation of chance. Operationalized, this hypothesis predicted that whilst misrepresentation of chance and proneness to conjunction correlated positively, conjunction would explain little unique variance in belief in the paranormal.

Additionally, the present study investigated whether susceptibility to heuristic bias varied as a function of belief type. Research suggests that paranormal beliefs are multi rather than unidimensional. Particularly, top-down purification of the Revised Paranormal Belief Scale by Lange, Irwin, and Houran (2000) produced two correlated item sets, New Age Philosophy and Traditional Paranormal Beliefs (Houran, Irwin, & Lange, 2001). These clusters distinguish paranormal beliefs in terms of function (individual vs. social). New Age Philosophy (psi, witchcraft, spiritualism and astrology) functions at the individual/personal level and instils a sense of control over external events (Irwin, 1992), whereas Traditional

Paranormal Beliefs (traditional religious beliefs, witchcraft and precognition) manage external events at a social cultural level (Goode, 2000). Accordingly, personal experiences reinforce New Age Philosophy and cultural events strengthen Traditional Paranormal Beliefs.

There is tentative evidence to suggest these differences may influence susceptibility to heuristic bias. For example, Dagnall et al. (2014) observed that although perception of randomness correlated weakly with both New Age Philosophy and Traditional Paranormal Beliefs, conjunction correlated only Traditional Paranormal Beliefs. This finding was consistent with other related work. Particularly, Hergovich & Arendasy (2005) reported that participants with lower reasoning ability had higher belief scores on both measures, and that the effect for Traditional Paranormal Beliefs was stronger

Furthermore, Wilson (2012) observed that Traditional Paranormal Beliefs best predicted vitalism (reliance upon explanations involving vital energies/forces) when participants were asked to provide open responses. Contrastingly, only New Age Philosophy predicted vitalism when participants selected from possible causal explanations (experiment 1). Based on these findings, Wilson (2012) concluded that endorsement of Traditional Paranormal Beliefs encourages generation of paranormal explanations under conditions of ambiguity. These results support the notion that the two paranormal belief factors function in different ways and have differential effects on reasoning. The present study investigated this notion. Based on previous research Traditional Paranormal Beliefs were predicted to be more strongly associated with heuristic bias generally and conjunction specifically.

Finally, the present paper extended examination of framing effects. Alongside standard situations, problems appeared couched (framed) within a paranormal context. This included paranormal based misrepresentation of chance problems. Previous studies manipulating conjunction context failed to explore the effects of framing on misrepresentation of chance. For this reason and because framing manipulations have formerly produced inconsistent results, only tentative predictions were proffered. It was anticipated that standard problems would be harder to solve than those presented in a paranormal context. Additionally, observed differences between problem types (misrepresentation of chance and conjunction) would reduce when the problems appeared within a paranormal context; previously problems framed in a paranormal context proved easier to solve than standard problems, however this advantage was less pronounced in paranormal believers (Dagnall et al., 2014).

METHOD

Participants

A sample of 223 participants (57 male participants, 26% and 166 female participants, 74%) took part in the study. Participant mean age was 23.00, *SD* = 8.41; ages ranged from 18-56 years. The mean for males was 24.85, *SD* = 9.78; range 18-65 years, and for females the mean was 22.36, *SD* = 7.82; range 18-61 years.

Participant recruitment was via emails to undergraduate and postgraduate students (Health & Social Care and Arts & Humanities courses at Manchester Metropolitan University), local vocational/sports clubs, leisure classes and businesses in the Northwest. The sample comprised 67% enrolled undergraduate students (Health & Social Care, 89% and Arts & Humanities, 11%) and 33% non-students. Prior to participation, a question asked whether participants had previously studied heuristic bias. If participants endorsed the question, participation discontinued.

Materials

Probabilistic reasoning tasks

The reasoning section comprised 20 problems divided into five sections, each containing one of four problem types:

Perception of randomness

Problems assessed participants' ability to judge accurately perception of chance, particularly the likelihood of strings/sequences (e.g., 'imagine a coin was tossed six times. Which pattern of results do you think is most likely? (a) HHHHHH, (b) HHHTTT, (c) HTHHTT, (d) all equally likely').

Conjunction fallacy

Participants selected the most likely outcome from a range of presented alternatives. These took the form of statements involving either single or co-occurring events (e.g., 'two football teams (Team A and Team B) are playing in a local derby. What is the most likely outcome of the game?: (a) Team A scores first, (b) Team A scores first and wins, (c) Team A scores first and loses, (d) Team A scores first and the game is drawn').

Paranormal conjunction fallacy

Paranormal problems possessed the same underlying structure as standard conjunctions; the probability of event intersection could not exceed the probability of single constituent events (*cf.* Tversky & Kahneman, 1982, 1983). The only difference being that paranormal conjunction fallacy problems appeared within a paranormal context. For instance, 'Andrew often sits by the telephone at work. Just as he is thinking about his friend, she rings: (a) Elaine rang because Andrew was thinking about her [event intersection], (b) Andrew was thinking about Elaine because she was about to ring [event intersection], (c) Elaine rang [single event])'.

Perception of randomness, conjunction fallacy and paranormal conjunction fallacy problems derived from Dagnall et al. (2007, 2014).

Paranormal perception of randomness

The fourth problem type, paranormal perception of randomness involved presenting string/sequence probability judgments in a paranormal context. Paranormal perception of randomness problems possessed the same underlying structure as standard perception of randomness problems. For example, 'A famous psychic, with renowned paranormal abilities, has successfully predicted the outcome of the last 6 annually held boat races between two famous English Universities [University A and University B]. This year the psychic predicts University B will win. Which of the following is most likely?: (a) University A will win the event , (b) University B will win the event, (c) University A and University B are both equally as likely to win the event.

Counterbalancing problem type order controlled for potential order effects.

Revised Paranormal Belief Scale

The Revised Paranormal Belief Scale (Tobacyk & Milford, 1983, Tobacyk, 1988) is a self-report measure that assesses belief in seven facets of paranormal belief: psi, witchcraft, spiritualism, superstition, traditional religious belief, extraordinary life forms and precognition. The Revised Paranormal Belief Scale contains 26 questions presented as statements (e.g., 'There is a devil'), responses are measured via a seven-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree). Purification of the Revised Paranormal Belief Scale by Rasch scaling requires responses to be recoded (0-6) (Lange et al., 2000). Recoding produces summative scores ranging from 0 to 156, higher scores indicate belief in the paranormal. Scale purification lead to the identification of two psychometrically superior factors, New Age Philosophy and Traditional Paranormal Beliefs.

New Age Philosophy (11-items) evaluates belief in psi, reincarnation, altered states and astrology, whereas Traditional Paranormal Beliefs (5-items) assesses belief in concepts, such as the devil and witchcraft (Irwin, 2004). New Age Philosophy scores range from 6.85 to 47.72 and Traditional Paranormal Beliefs 11.16 to 43.24 (Andrich, 1988). The Revised Paranormal Belief Scale is the most widely used measure of paranormal belief (Goulding & Parker, 2001). Despite, concerns about the factorial structure of the Revised Paranormal Belief Scale (Lawrence, 1995a, 1995b), the measure demonstrates adequate validity (Tobacyk, 2004). Overall, the Revised Paranormal Belief Scale is a conceptually and psychometrically satisfactory measure of paranormal belief (Tobacyk, 2004). Within studies examining relationships between belief in the paranormal and cognitive biases, the Revised Paranormal Belief Scale has produced similar findings to the Australian Sheep–Goat Scale (see Dagnall et al., 2014). The present investigation preferred the Revised Paranormal Belief Scale because its factorial structure enabled the examination of relationships between specific belief types (New Age Philosophy and Traditional Paranormal Beliefs) and cognitive biases; the Australian Sheep–Goat Scale typically provides only a general index of core paranormal beliefs (extra-sensory perception, psychokinesis and life after death) (Wiseman & Watt, 2006).

Procedure

After assenting to take part, participants received the test booklet. This contained a set of instructions stating that under test conditions they must attempt to answer all questions. On completion of the problems, participants filled in a copy of the Revised Paranormal Belief Scale. At the conclusion of testing, the researcher debriefed the participants. All aspects of the study followed the protocols and procedures outlined within the British Psychological Society (2009) ethical guidelines. The study was part of an ethically approved ongoing funded research project.

RESULTS

Scale properties and inter-measure correlations

Following data screening, the researchers calculated the means, standard deviations and bivariate correlations for each scale. The Revised Paranormal Belief Scale (R-PBS) demonstrated excellent internal reliability, Cronbach's alpha (α = .93). Revised Paranormal Belief Scale subscales, New Age Philosophy (NAP) (α = .89) and Traditional Paranormal Beliefs (TPB) (α = .82) possessed good internal reliability (George & Mallery, 2003) (see Table 1).

INSERT TABLE 1 HERE

Problem type descriptive statistics

Problem solution scores were calculated (perception of randomness, conjunction fallacy, paranormal perception of randomness, paranormal conjunction fallacy, overall standard, and overall paranormal). In Table 2, these appear as means and proportions alongside inter-problem correlations. Pearson product moment revealed positive correlations between problem types.

INSERT TABLE 2 HERE

Belief in the paranormal and problem task solution

A further set of Pearson product moment correlations found positive associations between belief in the paranormal and problem types (see Table 3).

INSERT TABLE 3 HERE

Analytical strategy

Analysis comprised a series of discrete but related sections. First, Harman's single-factor test evaluated common method variance (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003) and confirmatory factor analysis (using Amos version 21 with maximum likelihood estimation) assessed the measurement model for each scale. Next, composite reliability analysis appraised the reliability of each measure. Finally, structural equation modelling examined relationships between study variables.

Analysis tested four models. Model 1 and Model 2 examined whether perception of randomness and conjunction fallacy related negatively to belief in the paranormal. Previous research suggested that New Age Philosophy and Traditional Paranormal Beliefs emphasise different functions of paranormal beliefs (see introduction). Model 1 tested whether perception of randomness and conjunction fallacy related negatively to Traditional Paranormal Beliefs, and Model 2 examined whether perception of randomness and conjunction fallacy related negatively to New Age Philosophy. Both models predicted perception of randomness would be a stronger paranormal belief predictor than conjunction fallacy. Additionally, a stronger relationship was predicted between Traditional Paranormal Beliefs and proneness to conjunction than New Age Philosophy and proneness to conjunction.

Model 3 and Model 4 examined the hypotheses that the relationship between problems framed in a paranormal context and belief in the paranormal would be weaker. Framing problems in a paranormal context, potentially conflates problem-solving ability with paranormal belief. Models tested the assumption that paranormal perception of randomness and paranormal conjunction fallacy related negatively to Traditional Paranormal Beliefs (Model 3) and New Age Philosophy (Model 4). Both models proposed that perception of randomness problems would predict paranormal belief more strongly than paranormal conjunction.

Model fit was determined via consideration of absolute and relative fit indices. Absolute fit indices assess the degree to which a hypothetical model fits observed data (i.e. chi-square, standardized root mean-square residual and root mean-square error of approximation). Relative fit compares the proposed model and the chi-square value of the null model (i.e. Tucker Lewis Index – TLI, Tucker & Lewis, 1973; and Comparative Fit Index – CFI, Cronbach, 1990). A range of goodness-of-fit statistics assessed model fit.

Chi-square (χ^2) evaluated the difference between the observed and expected covariance matrices; good fitting models produce non-significant results. Chi-square however, is influenced by sample size; small samples are associated with type I errors and large samples type II errors (Tanaka, 1987). Thus, additional indices gauged model fit. The Comparative Fit Index – CFI and the Tucker Lewis Index – TLI compare data to a baseline model where all variables are uncorrelated. Values above .90 indicate good fit and values above .95 specify very good model fit (Hu & Bentler, 1999). These criteria judged good to very good fit in accordance with absolute fit indices. Consistent with previous research, values above .88 indicates adequate fit and > .86 suggests marginal fit (e.g., Bong, Woo, & Shin, 2013; Doll, Hendrickson, & Deng, 1998; Nigg, Nikolas, Miller, Burt, Klump, & von Eye, 2009). Lower values are indicative of poor fit. Comparative Fit Index – CFI and the Tucker Lewis Index – TLI appear alongside standardized root mean-square residual (SRMR: Jöreskog & Sörbom, 1981) and root mean-square error of approximation (RMSEA: Steiger, 1990). Ideally, standardized root mean-square residual – SRMR should be less than .05; however, values less than .08 suggest adequate fit and values above .10 indicate poor fit (Hu & Bentler, 1999). For root mean-square error of approximation – RMSEA values below .05 specify close fit, values between .06-.08 indicate adequate fit, .08 to .10 suggest marginal fit, and values above .10 signify poor fit (Browne & Cudeck, 1993). These criteria determined model fit alongside relative fit indices.

Harman's single-factor test

Harman's single-factor test assessed whether common method variance was a problem within the present data set. Common method variance refers to variance attributable to the measurement method rather than the constructs measured. Common method variance is potentially an issue when dependent and focal explanatory variables are perceptual measures derived from the same respondent (Podsakoff & Organ, 1986). Common method variance within cross-sectional studies may produce correlation inflation (Lindell & Whitney, 2001). Computation of Harman's single-factor test occurred via confirmatory factor analysis, which hypothesized that all scale items loaded onto a single latent factor. Results indicated poor model fit for the one-factor model on all criteria but RMSEA: χ^2 (593) = 1586.032, $p < .001$; CFI = .67; RMSEA = .09; SRMR = .09; TLI = .65. This outcome signifies that relationships represented distinct constructs and did not arise from common method variance. Confirmatory factor analysis examined construct structure also.

Confirmatory factor analyses

Theoretically driven confirmatory factor analysis indicated satisfactory two-factor correlated models for belief in the paranormal, standard problems and problems framed within a paranormal context. Although the chi-square value for the two-factor Revised Paranormal Belief Scale model was significant, χ^2 (99) = 345.29, $p < .001$, fit indices met the criteria for marginal fit: CFI = .88; RMSEA = .10; SRMR = .07; TLI = .86. Comparative Fit Index – CFI and the Tucker Lewis Index – TLI values of .88 and .86 respectively indicated marginal fit (Bonget al. 2013; Doll et al. 1998; Nigg et al. 2009). The two-factor correlated model for standard problems (perception of randomness and conjunction fallacy) displayed a non-significant chi-square and all fit indices met the criteria for very good fit: χ^2 (34) = 35.17, $p >$ .05; CFI = .99; RMSEA = .01; SRMR = .05; TLI = .99. The two-factor correlated model for problems in a paranormal context (paranormal perception of randomness and paranormal conjunction fallacy) possessed a significant chi-square, χ^2 (33) = 79.99, $p < .001$; however, fit indices suggested good data-model fit for CFI and SRMR (.91 and .05 respectively), an adequate RMSEA value (.08) and a marginal TLI value (.87).

Adequacy of the two-factor correlated models was determined also in relation to parameter estimates. All factor loadings, except one, were positive and statistically significant. Generally, items possessed factor loadings greater than the minimum threshold of .32 (Tabachnick & Fidell, 2001). The majority of indicators exhibited factor loadings above .60, satisfying the strict factor loading requirements of Hair, Anderson, Tatham, and Black (1998).

Reliability analysis

Latent modelling cautions that traditional measures of internal reliability (i.e. Cronbach's α) over or underestimate scale reliability (Raykov, 2002). In this context, composite reliability provides a more rigorous assessment of internal reliability. When considering composite reliability, values greater than .60 are acceptable (Diamantopoulos & Siguaw, 2000). Results for the standard problems indicated that perception of randomness (ρc = .89) and conjunction fallacy (ρc = .71) possessed satisfactory composite reliability. Problems framed in a paranormal context, paranormal perception of randomness, and paranormal conjunction fallacy possessed satisfactory composite reliability (ρc =.60 and ρc = .64 respectively). Finally, Traditional Paranormal Beliefs and New Age Philosophy demonstrated also satisfactory composite reliability (ρc =.60 and ρc = .60 respectively).

Model test

Standard problem types with paranormal beliefs

INSERT TABLE 4 HERE

Fit indices for Model 1 (standard problem types with Traditional Paranormal Beliefs) and Model 2 (standard problem types with New Age Philosophy) appear in table 4. For Model 1, chi-square was non-significant, χ^2 (83) = 93.26, $p > .05$. Inspection of fit indices indicated a very good fit for the proposed theoretical model (CFI = .99, TLI = .98, SRMR = .05, RMSEA = .02). Model 2 revealed a significant chi-square, χ^2 (184) = 285.84, $p < .001$. Fit indices, however, demonstrated a good fit to these data for the proposed theoretical model (CFI = .93, TLI = .91, SRMR = .05, RMSEA = .05). All relationships were in the expected direction and supported the prediction that performance on perception of randomness and conjunction fallacy problems relates negatively with belief in the paranormal (Traditional Paranormal Beliefs and New Age Philosophy) (see Figure 1 and Figure 2). Conjunction fallacy demonstrated weaker relationships with Traditional Paranormal Beliefs and New Age Philosophy (than perception of randomness). This is evident from the significant direct paths from perception of randomness to both Traditional Paranormal Beliefs in Model 1 (β = -.42, $p < .001$) and New Age Philosophy in Model 2 (β = -.34, $p <.05$). In comparison, paths from conjunction fallacy to Traditional Paranormal Beliefs in Model 1 (β = -.14, $p > .05$) and New Age Philosophy in Model 2 (β = -.06, $p > .05$) were non-significant.

Furthermore, a positive (though non-significant) relationship was evident between perception of randomness and conjunction fallacy (β = .23, $p > .05$). Model comparison suggested a stronger relationship between problem types and Traditional Paranormal Beliefs.

Partial correlation identified unique variance between each problem type and belief in the paranormal. Relationships between perception of randomness and belief in the paranormal (controlling for conjunction fallacy) were significant (perception of randomness and TBP, $r = -.27$, df = 220, $p < .001$; perception of randomness and New Age Philosophy, $r = -.17$, df = 220, $p < .05$). Contrastingly, correlations between conjunction fallacy and belief in the paranormal (controlling for perception of randomness) were not significant (conjunction fallacy and TBP, $r = -.11$, df = 220, $p > .05$; conjunction fallacy and New Age Philosophy, $r = -.04$, df = 220, $p > .05$).

INSERT FIGURE 1 & FIGURE 2

Problems framed within a paranormal context with paranormal beliefs

INSERT TABLE 5 HERE

Fit indices for Model 3 (paranormal problem types with Traditional Paranormal Beliefs) and Model 4 (paranormal problem types with New Age Philosophy) appear in table 5. The results for Model 3 show a significant chi-square, χ^2 (83) = 190.86, $p < .001$. Inspection of relevant fit indicated an adequate fit to the data for the proposed model (CFI = .90, TLI = .88, SRMR = .08, RMSEA = .07). Model 4 also specified adequate data-model fit: χ^2 (184) = 363.86, $p < .001$; CFI = .90; TLI = .88; SRMR = .06; RMSEA = .07. All relationships were in the expected direction. Paths between paranormal perception of randomness and Traditional Paranormal Beliefs in Model 3 ($\beta = -.15$, $p > .05$) and between paranormal perception of randomness and New Age Philosophy in Model 4 ($\beta = -.14$, $p > .05$) were non-significant.

Given the significant direct path existed between paranormal conjunction fallacy and New Age Philosophy (β = -.49, p < .05) a stronger relationship was evident between paranormal conjunction fallacy and New Age Philosophy (Model 4) than Traditional Paranormal Beliefs (Model 3). In comparison with Models 1 and 2, fit indices for Models 3 and 4 indicated that framing problems in a paranormal context weakened the relationship between problem-solving ability and belief in the paranormal (Traditional Paranormal Beliefs and New Age Philosophy). The positive relationship between paranormal problems (paranormal perception of randomness and paranormal conjunction fallacy) was significant and stronger (β = .76, p < .001) than that observed for standard problem types (perception of randomness and conjunction fallacy).

Partial correlation identified unique variance between each paranormal problem type and belief in the paranormal. Relationships between paranormal perception of randomness and belief in the paranormal (controlling for paranormal conjunction fallacy) were significant (paranormal perception of randomness and Traditional Paranormal Beliefs, r = -.19, df = 220, p = .005; paranormal perception of randomness and New Age Philosophy, r = -.18, df = 220, p = .005. Similarly, correlations between paranormal conjunction fallacy and belief in the paranormal (controlling for paranormal perception of randomness) were not significant (paranormal conjunction fallacy and Traditional Paranormal Beliefs, r = - .25, df = 220, p > .001; conjunction fallacy and New Age Philosophy, r = -.25, df = 220, p > .05.

DISCUSSION

Consideration of the proposed models assessing relationships between problem types and belief in the paranormal produced several important finding. With regard to standard problem types, perception of randomness was more strongly associated with belief in the paranormal than susceptibility to conjunction fallacy. Perception of randomness correlated negatively with belief in the paranormal. Examination of Revised Paranormal Belief Scale factors (Traditional Paranormal Beliefs and New Age Philosophy) revealed small but significant correlations. These findings replicate those of Dagnall et al. (2007, 2014) and support the notion that belief in the paranormal arises from a specific bias associated with perception of randomness (misrepresentation of chance). Conjunction error, however, correlated only with Traditional Paranormal Beliefs. This finding was consistent with Dagnall et al. (2014) and substantiated the supposition that susceptibility to conjunction error is only weakly associated with belief in the paranormal.

Results also concur, with Brotherton and French (2014) who reported weak relationships between belief in the paranormal and various conjunction types (neutral, $r = .19$; paranormal, $r = .20$; conspiracy, $r = .13$; and overall, $r = .20$). The small underlying correlations reported across comparable previous studies require relatively large sample sizes to reach statistical significance. For example, when sampling from a population with the same effect size with alpha set as .05, an *observed* effect size $r = .20$ requires $N \geq 97$: $r(95) = .20$, $p = .05$, two-tailed, 95% CI [.001, .38], and sample sizes of N = 192 are required for approximately 80% power (Cohen, 1988). Thus, differences in power may explain the inconsistent nature of statistical significance within conjunction fallacy work. Furthermore, low statistical power within studies may give rise to inflated effect size reporting (i.e. when employing small samples from a population with a small effect size), hence emphasis should be placed upon those observed effects 'large enough' for statistical significance (Button et al., 2013). Overall, a cautious interpretation of reported associations is required, particularly when assessed against statistical thresholds. Before forming definitive conclusions authors should consider their observed correlation strength alongside those reported within similar published studies. In the case of conjunction fallacy, studies cumulatively evidence only a weak relationship with belief in the paranormal.

Within the present study, the observed relationship between conjunction fallacy and belief in the paranormal concurs with Rogers et al.'s (2009, 2011) observation that paranormal believers (vs. non-believers) made more conjunction errors. This result, however, requires further examination. Consideration of partial correlations between standard problem types and belief in the paranormal revealed that conjunction fallacy explained only a small (non-significant) amount of unique variance. Contrastingly, correlations between perception of randomness and paranormal belief, controlling for conjunction fallacy, reduced only slightly and remained significant.

These findings support the notion that conjunction fallacy correlates with belief in the paranormal because it shares common variance with perception of randomness. In the context of paranormal belief, it appears that conjunction fallacy may represent a specific instance of perception of randomness; one where believers mistakenly attribute causal relationships to co-occurring events (Blackmore & Troscianko, 1985; Bressan, 2002; Brugger & Taylor, 2003; Gilovich & Savitsky, 2002). Rogers (2014) concurs with this view and notes that earlier work appeared to suggest that belief in the paranormal was associated with two separate types of probabilistic reasoning bias, misperception and conjunction. However, differences between the two biases diminish when conjunction is conceptualised as the co-occurrence of unrelated component parts. Thus, believers' proneness to conjunction error reflects merely their tendency to misperceive random events as causally related (Rogers, 2014). This interpretation fits intuitively and empirically with previous work and is consistent with Arnott's (1998, 2006) classification system. Arnott's system when applied to the study of belief in the paranormal, predicted that misperception of chance would be the best predictor of belief in the paranormal and that any observed relationship between conjunction and paranormal belief would be attributable to common membership of a statistical bias category.

Collectively, results for standard problem types support previous work demonstrating a stronger relationship between perception of randomness and belief in the paranormal (than conjunction fallacy; Dagnall et al., 2007; 2014). With reference to the formative Dagnall et al. (2007) paper, consistent misreporting undermined the credibility of the original findings (*cf.* Brotherton & French, 2014; Rogers et al., 2009; 2011; see Dagnall et al., 2014 for explication and correction). Replications using different samples, a range of problems and various paranormal measures (Revised Paranormal Belief Scale, Australian Sheep–Goat Scale and Manchester Metropolitan University-New; Dagnall et al., 2014) have demonstrated the robust nature of the perception of randomness paranormal belief relationship and the weaker association of conjunction fallacy.

Secondly, framing problems within a paranormal context strengthened the relationship between problem types, as evidenced by the high positive correlation between paranormal perception of randomness and paranormal conjunction fallacy. Consequently, similar moderate negative correlations arose between paranormal framed problems and measures of belief in the paranormal (overall belief, Traditional Paranormal Beliefs and New Age Philosophy); correlation size differences between Traditional Paranormal Beliefs and New Age Philosophy reduced. Jointly, these findings suggest that presenting problems within a paranormal context weakens problem ability to predict belief in the paranormal. Indeed, framing problems within a paranormal context is methodologically problematic. Context commonality increases problem similarity, correspondingly reducing the discriminatory power of individual problem types. Particularly, responses represent potentially conflated measures because scores index both proneness to heuristical bias and belief in the paranormal. Thus, it is unclear whether incorrect responses reflect question specific beliefs, or proneness to heuristical bias. Comparison of standard vs. paranormal framed items revealed that performance across framed problems (paranormal perception of randomness and paranormal conjunction fallacy) was similar and higher (vs. standard items). The results indicated that whilst paranormal framed problems were generally easier to solve, the advantage declined as a function of belief in the paranormal.

With regard to conjunction fallacy framed problems, previous work has produced inconsistent findings. Rogers et al. (2009) reported that believers and non-believers made fewer conjunction errors for paranormal than for non-paranormal events. Similarly, Dagnall et al (2014) observed a similar framing effect to that outlined by Rogers et al. (2009). Rogers et al. (2011), however, failed to replicate the framing effect. Clearly, before meaningful conclusions are drawn a thorough evaluation of framing effects within the current paradigm is required. For instance, future studies could manipulate paranormal contexts. Currently, framed problems index general paranormal beliefs, without consideration of belief type. It would be interesting to see whether specific paranormal beliefs, such as those associated with ESP, correlated with poor performance on ESP-related questions as opposed to items tapping into general paranormal belief (life after death, witchcraft, hauntings, astrology, etc.). Clearly, there is no reason to suppose that respondents, who believe in one aspect of the paranormal (e.g., ESP) will be similarly influenced by paranormally framed problems drawn from areas in which they are more sceptical (e.g., ghosts and hauntings). Framed problems, in this context provide only a crude/limited (belief specific) insight into heuristical bias.

Recent work by Brotherton and French (2014) attempted to extend work on reasoning bias and heuristics to conspiracist ideation. The authors reasoned that because belief in the paranormal and conspiracism represent forms of anomalous beliefs, as defined by defiance of conventional understanding of reality, they should be similarly related to conjunction fallacy. This is an oversimplification because not all anomalous beliefs arise and function in the same manner. Consideration of studies reporting associations between belief in the paranormal and conspiracist ideation reveal only a moderate relationship. For example, Drinkwater, Dagnall, and Parker (2012) reported that a general measure of conspiratorial ideation correlated positively with the Revised Paranormal Belief Scale (*r* = .38) and the Australian Sheep–Goat Scale (*r* = .34). Similarly, Lobato, Mendoza, Sims & Chin (2014) using a novel measure containing items from scales such as the Revised Paranormal Belief Scale and conspiracy acceptance (Goertzel, 1994, Abalakina-Paap, Stephan, Craig, & Gregory, 1999), reported a correlation of *r* = .52. Based on these studies, shared variance between belief in the paranormal and conspiracism is approximately 10%-25%. Thence, although overlap exists between these ‘anomalous beliefs’ there are important differences, which limit generalisations.

It would be apposite to investigate whether susceptibility to various forms of heuristical bias varies as a function of anomalous belief type. Thus, while perception of randomness appears related to belief in the paranormal, there is no reason to assume perception of randomness is similarly associated with conspiracist ideation. With conspiratory thinking, logic is confounded when an individual’s acceptance of alternative explanations arises from the perceived inadequacy of official, prevailing accounts. For instance, inaccuracies within the official Roswell, 1947 account do not provide evidence to support the notion that an alien craft crashed (Nickell, 2009; Thomas, 1995). In this respect, endorsement of conspiracy theories mirrors superficially the structure of conjunction errors. Thus, although conjunction fallacy is weakly associated with belief in the paranormal, susceptibility to conjunction error may link more strongly to endorsement of conspiracy theories (Brotherton & French, 2014).

Conclusion

This study adds to the emerging body of evidence advocating an association between belief in the paranormal and perception of randomness (Blackmore & Troscianko, 1985; Tobacyk &

Wilkinson, 1991). Pragmatically, perception of randomness manifests as misrepresentation of chance and results in believers (vs. non-believers) misattributing causality to random, coincidental events (Bressan, 2002; Brugger & Taylor, 2003; Gilovich & Savitsky, 2002). Previous work elucidates that this reflects believers' tendency to base judgements on subjective perceptions/interpretations rather than the objective laws of probability (Rogers et al., 2009). Considering the prosaic nature of paranormal beliefs within modern society (Castro, Burrows, & Wooffitt, 2014) misperception of chance appears to reflect an information processing preference not a cognitive deficit (Dagnall et al., 2014).

With regard to heuristic bias, the results support previous work reporting a stronger relationship between perception of randomness and belief in the paranormal than conjunction fallacy (Dagnall et al., 2007; 2014). There was no evidence to suggest that conjunction fallacy was/is a major factor associated with the development and maintenance of paranormal beliefs. Framing manipulations indicated that whilst paranormal framed problems were easier to solve, the advantage declined as a function of belief in the paranormal. However, methodological concerns/issues limit the degree to which framing manipulations provide insights into the relationship between heuristical bias and paranormal belief.

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Tables

Table 1. Scale descriptive statistics and correlations

	α	*Mean*	*SD*	*Min*	*Max*	1	2	3
1. R-PBS	.93	74.09	29.15	29.00	167.00			
2. NAP	.89	20.43	5.63	6.85	33.53	.86**		
3. TPB	.82	21.09	5.78	11.16	43.24	.86**	.74**	

R-PBS = Revised Paranormal Belief Scale; NAP = New Age Philosophy; TPB = Traditional Paranormal Belief

** $p < .01$

Table 2. Problem type accuracy descriptive statistics

	Total		Proportion					
Problem type	*M*	*SD*	*M*	*SD*	1	2	3	4
Perception of Randomness	3.74	1.11	0.75	0.22				
Conjunction Fallacy	1.87	1.28	0.37	0.26	.18**			
Paranormal Perception of Randomness	4.44	1.11	0.89	0.22	.23**	.25**		
Paranormal Conjunction Fallacy	4.29	1.11	0.86	0.22	.40**	.14*	.54**	
Overall Standard	2.80	0.92	0.56	0.18				
Overall Paranormal	4.36	0.97	0.87	0.19				
Problem-Solving Total	14.34	3.13	0.72	0.16				

* $p < .05$; ** $p < .01$

Table 3. Correlations between belief in the paranormal and problem type accuracy

Problem type	R-PBS	NAP	TPB
Perception of Randomness	-.25**	-.18**	-29**
Conjunction Fallacy	-.12*	-.07	-.15*
Paranormal Perception of Randomness	-.43**	-.34**	-.36**
Paranormal Conjunction Fallacy	-46**	-.38**	-.39**
Overall Standard	-.23**	-.16**	-.28**
Overall Paranormal	-.51**	-.41**	-.42**
Problem-Solving Total	-.45**	-.35**	-.43**

* $p < .05$; ** $p < .01$. R-PBS = Revised Paranormal Belief Scale; TPB = Traditional Paranormal Beliefs; NAP = New Age Philosophy

Table 4. Fit indices for Models 1 and 2

Model	χ^2	df	CFI	TLI	SRMR	RMSEA
Standard Problem Type with TPB	93.26	83	.99	.98	.05	.02
Standard Problem Type with NAP	285.84***	184	.93	.91	.05	.05

Note. N = 223; TPB = Traditional Paranormal Beliefs; NAP = New Age Philosophy; χ^2 = chi square goodness of fit statistic; df = degrees of freedom; CFI = Comparative Fit Index; TLI = Tucker Lewis Index; SRMR = Standardized Square Root Mean Residual; RMSEA = Root-Mean-Square Error of Approximation; *** Indicates χ^2 are statistically significant ($p < .001$).

Table 5. Fit indices for Models 3 and 4

Model	χ^2	df	CFI	TLI	SRMR	RMSEA
Paranormal Problem Type with TPB	190.86***	83	.90	.88	.08	.07
Paranormal Problem Type with NAP	363.86***	184	.90	.88	.06	.07

Note. $N = 223$; TPB = Traditional Paranormal Beliefs; NAP = New Age Philosophy; χ^2 = chi square goodness of fit statistic; df = degrees of freedom; CFI = Comparative Fit Index; TLI = Tucker Lewis Index; SRMR = Standardized Square Root Mean Residual; RMSEA = Root-Mean-Square Error of Approximation; *** Indicates χ^2 are statistically significant ($p < .001$).