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Thinking style and psychosis proneness do not predict false insights

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ABSTRACT

The FIAT paradigm (Grimmer et al., 2021) is a novel method of eliciting 'Aha' moments for incorrect solutions to anagrams in the laboratory, i.e. false insights. There exist many documented reports of psychotic symptoms accompanying strong feelings of 'Aha!' (Feyaerts, Henriksen, Vanheule, Myin-Germeys, & Sass, 2021; Mishara, 2010; Tulver, Kaup, Laukkonen, & Aru, 2021), suggesting that the newly developed FIAT could reveal whether people who have more false insights are more prone to psychosis and delusional belief. To test this possibility, we recruited 200 participants to take an adapted version of the FIAT and complete measures of thinking style and psychosis proneness. We found no association between experimentally induced false insights and measures of Schizotypy, Need for Cognition, Jumping to Conclusions, Aberrant Salience, Faith in Intuition, or the Cognitive Reflection Task. We conclude that experiencing false insights might not be constrained to any particular type of person, but rather, may arise for anyone under the right circumstances.

1. Introduction

"The road to creativity passes so close to the madhouse and often detours or ends there." - Ernest Becker, The Denial of Death.

In his Pulitzer Prize-winning book, sociologist Ernest Becker articulates a natural mystery of human thought: how can we tell the difference between creative insight and delusion? Feelings of sudden realisation, also called insight moments or 'Aha' experiences, are reliably associated with correct solutions (Bowden & Jung-Beeman, 2003; Danek et al., 2014; Hedne et al., 2016; Kounios & Beeman, 2009; Laukkonen et al., 2018; Salvi et al., 2016; Webb et al., 2016). However, the phenomenon of false insights—feelings of insight accompanying incorrect solutions—has remained elusive and difficult to induce in laboratory settings, until recently (Grimmer et al., 2022). If incorrect ideas can feel true through the same processes as correct ones (Grimmer et al., 2022), research on insight phenomenology might reveal how and why some people come to believe in false and potentially dangerous ideas. In this study, we aim to discover whether individual differences in thinking style and psychosis proneness are associated with false insights.

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1.1. The history of insight research

Insight has been studied in various domains such as problem-solving (Köhler, 1925; Metcalfe & Wiebe, 1987; Ohlsson, 1984), psychotherapy (Connolly Gibbons et al., 2009; Jennissen et al., 2018), neuroscience (Kounios & Beeman, 2009; Sandkühler & Bhattacharya, 2008), and meditation (Cousins, 1996; Laukkonen & Slagter, 2021). After more than a century of research (Bühler, 1907; Köhler, 1925), insight moments are generally defined as the sudden appearance of a solution to a problem appearing in consciousness providing a new sense of understanding (Tulver et al., 2021).

Research on insight dates back to the Gestalt psychologists (Bühler, 1907; Koffka, 1935; Köhler, 1925), who introduced insight as a special type of problem-solving process. Frequently contrasted with slow, analytical problem-solving (Metcalfe, 1986; Weisberg, 2006), insight occurs most often when a problem-solver is initially stymied and has made little progress towards solution (Kounios et al., 2006; Webb et al., 2016).

Recent studies have been particularly concerned with the phenomenology of insight—the subjective rush of emotions such as satisfaction, surprise, confidence, and understanding (Danek & Wiley, 2017; Jung-Beeman et al., 2004; Topolinski & Reber, 2010; Webb et al., 2016; Webb et al., 2017). These phenomena are thought to be a metacognitive signal of truth (Danek & Salvi, 2020; Laukkonen et al., 2018; Sandkühler & Bhattacharya, 2008), and until recently, false insights were generally overlooked as rare aberrations. However, recent work shows that insight moments can lead to incorrect solutions (Danek & Wiley, 2017; Stuyck et al., 2021), but due to their rarity, false insights were scarcely addressed in experimental contexts, until recently.

1.2. False insights

False insights were documented when they arose naturally in prior research, but they can now be induced experimentally. Grimmer and colleagues (Grimmer et al., 2022) developed a new paradigm to elicit 'Aha' moments for incorrect anagram solutions, known as the *False Insights Anagram Task* (FIAT). In these experiments, participants read lists of semantically related words (e.g., REMEMBER, SIGNIFICANT, HONOUR, TRIBUTE, MEMORIAL, STATUE, etc.) then solved anagrams that were either visually similar to an associate of the studied lists (i.e., another word that shares the same sematic relation to the studied list, such as, KRMDNAAL - LANDMARK) or a range of controls. Grimmer et al. found that participants reported higher rates of false insights for the anagrams that were visually similar to a primed associate, but were incorrect (e.g., MEMUNOMT - MOMENTUM) than for the control anagrams. These findings demonstrate that false 'Aha' experiences can be induced experimentally, via semantic priming and visual similarity, with the accuracy of insights depending heavily on whether the available information induces accurate or inaccurate associations. In a recent study by Ammalainen and Moroshkina (2020), participants solved anagrams that contained another solution—another word that was shorter by one letter—some anagrams were accompanied by pictorial hints that were either relevant to the correct solution or the shorter word. The researchers found that when the pictorial hint was relevant to the shorter incorrect solution, participants were more likely to arrive at that solution than when the hint was associated with the correct solution.

Insight phenomenology, even for correct solutions, can also be misleading when the insight experience itself triggers false beliefs through a process of "misattribution" (Laukkonen et al., 2021; Laukkonen et al., 2020). For example, if a proposition such as "humans have free will" is presented at the same time that an 'Aha' moment is artificially elicited, participants will tend to rate the proposition as more believable or true (Laukkonen et al., 2021). This misattribution effect presumably occurs because the 'Aha' feeling contaminates the judgments involved in evaluating the claim that is presented at the same moment—the feeling of truth triggered by the 'Aha' experience is "heuristically" misattributed to the claim itself (Laukkonen et al., 2018).

This finding suggests that not only can the content of an insight be false (cf. Grimmer et al., 2022), but the feeling itself can lend a sense of unfounded plausibility to other content that is presented simultaneously (Laukkonen et al., 2020; 2021). These two aspects of the insight experience could possibly play a mutually reinforcing role, for example in the development of delusional beliefs, whereby a false idea appears in an insight, and the feeling of truth associated with the insight further confirms other beliefs the individual has, recursively entrenching them into a delusional framework (Feyaerts et al., 2021; Mishara & Corlett, 2009; Sips, 2018; Sips et al., 2021; Van Duppen & Feyaerts, 2021).

1.3. Understanding false insights

The findings of the above experiments create an opportunity to address important questions about the cognitive mechanisms that underlie people's susceptibility to false insights. Understanding false insights has implications for delusions, conspiracy beliefs, and misinformation (Webb et al., 2019). As with other paradigms used in cognitive science to illustrate flaws in reasoning or memory, the FIAT works to varying degrees for different people. In Grimmer et al. (2022), 9.3% of participants experienced no false insights, 1.3% experienced a false insight for every primed lure, and 44.6% of participants had false insights on at least half the trials. Research on other error-oriented paradigms, such as the Cognitive Reflection Task and the DRM task, has revealed other individual differences that correlate with inter-individual variability on these tasks (Dehon, Larøi, & Linden, 2011; Pennycook & Rand, 2019; Watson et al., 2005). We reasoned that the false insight task might similarly correlate with individual differences that tap susceptibility to error-prone thinking.

1.3.1. False insights and false memories: The influence of thinking style

To guide our investigation into individual differences that might correlate with false insights, we examined research on the effect that inspired the FIAT paradigm—the false memory paradigm created by Roediger and McDermott (1995). We reasoned that correlates

of the DRM effect might also be associated with the FIAT effect due to their conceptual similarity. Although false insights on the FIAT were not correlated with false memories in Grimmer et al. (2022), the methods of that study did not allow for a proper test of the potential relationship between the DRM and the FIAT. Nonetheless, the DRM effect correlates with several individual differences that may be relevant to the FIAT. For example, false memories in the DRM positively predict people's scores on misinformation false memory tasks (Zhu et al., 2013), and people who have more false memories on the DRM task also tend to report more instances of anomalous experiences, UFO sightings, and magical thinking (Clancy et al., 2002; Corlett et al., 2009, French et al., 2008). Individuals who score highly on the DRM are also more likely to report specific memories from past lives (Meyersburg et al., 2009). These findings suggest that the DRM might tap various individual differences that contribute to proneness to memory contamination. Indeed, people who have more false memories appear to believe things based on limited empirical evidence, relying heavily on their subjective experiences with little reflection.

Perhaps the most fundamental difference in thinking style is the tendency to engage in intuitive versus analytic thought (Evans, 2003; Kahneman, 2011). One of the most popular measures of people's tendency to engage in analytic thinking is the Cognitive Reflection Test (CRT, Frederick, 2005)—a three-item test designed to elicit an intuitive but incorrect answer to each question that participants must deliberately override to answer correctly. The CRT is a reliable predictor of many traits and behaviours. For example, people who answer intuitively on the CRT are more likely to believe in fake news (Pennycook & Rand, 2019,2020), conspiracy theories (Ballová Mikušková, 2018), and epistemically suspect beliefs in aliens, ghosts, and pseudoscience (Browne et al., 2015; Cheyne & Pennycook, 2013; Pennycook et al., 2012). People who answer the CRT intuitively also have more false memories in the DRM task (Nichols & Loftus, 2019).

Thinking style can also assessed with self-report measures of the propensity to engage in effortful, deliberative thought, such as the Need for Cognition Scale (Cacioppo & Petty, 1982). Need for Cognition negatively predicts belief in conspiracy theories (Georgiou et al., 2019, 2021, Stanley et al., 2021; Swami et al., 2014), although it does not appear to predict DRM false memories (Graham, 2007; Nichols & Loftus, 2019). A newer scale by Pacini and Epstein (1999) called the Rational-Experiential Inventory (REI) comprises a revised version of the Need for Cogntion scale and an opposite factor called Faith in Intuition. In the current study, we included both the CRT and the REI to test whether these measures of thinking style relate to the propensity for false insights.

1.3.2. False insights and delusions: Personality factors

Measures of analytic versus intuitive thinking have also been used to demonstrate how people with psychotic illnesses have difficulty with statistical and inferential reasoning (Dudley et al., 1997; Mækelæ et al., 2018; Reninghaus et al., 2019). Psychosis is particularly relevant to false insights, as anecdotes from sufferers of psychotic disorders often sound phenomenologically similar to 'Aha' experiences (Cicero et al., 2010; Kapur, 2003; Mishara, 2010; Mishara, 2012; Nasar, 2002; Sips, 2018). For example, in a qualitative study, Sips and colleagues (2021) interviewed psychosis patients and found that over two thirds of their sample described having insight experiences during their psychotic episodes. The similarities between psychosis and false insights have been noted in the insight literature (Laukkonen, Kaveladze, Tangen, & Schooler, 2020; Tulver et al., 2021; Webb, Little, & Cropper, 2016). For example, Webb and colleagues (2016) proposed that individuals with psychoses may be more likely to experience false insights but noted that this possibility would be difficult to test without further data on false insights. Given that we now have a paradigm that reliably induces false insights (Grimmer et al., 2022), we can tackle this problem directly.

Psychosis patients also show a reasoning bias known as Jumping to Conclusions (Dudley et al., 2016). This bias is measured with the so-called *beads task*, in which participants must decide which jar a sequence of coloured beads is being drawn from after being shown two jars containing opposite ratios of red and black beads (Dudley et al., 1997). People with psychotic disorders consistently make this decision based on significantly less information than healthy controls, often after seeing only one or two beads (Dudley et al., 2016). People prone to psychosis also score highly on a personality dimension called schizotypy, which is associated with unusual experiences and beliefs (Broyd et al., 2019; Ettinger et al., 2014). Along with jumping to conclusions, high schizotypy is consistently linked to poor performance on the CRT, more intuitive thinking on the REI, false memories, false perceptions, and conspiracy beliefs (Broyd et al., 2019; Bruder, Haffke, Neave, Nouripanah, & Imhoff, 2013; Dagnall & Parker, 2008; Hua, Karcher, & Kerns, 2020; Laws & Bhatt, 2005; Menon et al., 2013; Saunders, Randell, & Reed, 2011; Tsakanikos & Reed, 2005).

The findings described above suggest that overreliance on automatic, intuitive thinking is a key component in the aetiology of clinical psychosis (Mækelæ et al., 2018). In a similar vein, there is also extensive evidence that psychosis is a clinical manifestation of apophenia or aberrant salience—the tendencies to detect patterns where there are none and attribute meaning to random events (Blain et al, 2020; Blakemore, Sarfati, Bazin, & Decety, 2003; Kapur, 2003; Mishara, 2010; Reninghaus et al., 2019). Apophenia is often measured behaviorally on perceptual tasks (Blain et al., 2020; Fyfe et al., 2008; Galdos et al., 2011; Grant et al., 2014; Mohr et al., 2001), whereas Aberrant Salience is generally measured through self-report measures (Azzali et al., 2022; Cicero et al., 2010; Kapur, 2003; Scazza et al., 2021). Both phenomena are thought to be a consequence of dopamine dysregulation in the brain leading to psychosis (Blain et al., 2020; Kapur, 2003). Sips and colleagues (2021) note the similarity between experiences of aberrant salience and 'Aha' phenomenology, describing psychosis as a dialectic of 'Aha' and 'anti Aha' moments.

In sum, the existing literature suggests a possible relationship between thinking style, psychosis symptoms, and false memories. In the current study, we tested whether thinking styles relate to false insights in a similar manner. We predicted that people who experience more false insights on the FIAT will have higher scores on measures of psychosis proneness and lower scores on measures of analytic thinking styles. Specifically, we predicted that false insights will positively correlate with Aberrant Salience, Schizotypy, Faith in Intuition, and negatively correlate with Cognitive Reflection, Need for Cognition, and Jumping to Conclusions.

2. Method

2.1. Participants

To calculate the number of participants needed, we simulated a dataset and ran simulated analyses based on the population means of each measure, and our predicted intercorrelations between them (see SOM for the script and commentary for this analysis). Because we were uncertain about which measures will correlate highly, and because we anticipated that some may not correlate at all, we conducted our focal simulation analysis using a regression model with a specified R-squared value. This approach of simulating the data depends on fewer specific assumptions about correlations between all the variables, while isolating the FIAT as the predictor, thereby allowing any of the other measures to predict scores to varying degrees. The regression simulation indicated that a sample of 200 participants would be sufficient to test the predicted correlations between the FIAT and the various individual difference measures. Participants in this final sample were primarily recruited from Prolific Academic, but 62 participants were recruited from a pool of undergraduate psychology students (113 females, mean age = 26.4 years).

2.2. Materials

We selected several measures of cognitive traits that quantify the tendency to engage in analytical thinking and several measures of psychosis proneness. Below we describe these measures and our rationale for including them.

2.2.1. The false insight anagram task (FIAT)

The focal task in this study was a slightly modified version of the FIAT (full details at https://osf.io/nu3mr/). In the original paradigm, participants could experience a maximum of six false insights, and most participants experienced fewer (Grimmer et al., 2022). We also used a counterbalanced set of anagrams to ensure that our effect was not constrained to any particular set of materials. We found no difference between the counterbalancing conditions in either of our previous experiments and, therefore, in the current experiment, we decided to forgo counterbalancing the word lists, which gave us much greater freedom in our choices of which words to include.

To create a larger set of primed lure anagrams, we generated a set of potential word pairs using the SUBTLEX-UK Word Frequency Database for British English (van Heuven, Mandera, Keuleers, & Brysbaert, 2014) and selected all the 10, 11, 12, and 13 letter words with a Zipf score greater than 3 (which van Hueven et al., 2014, propose as the threshold between low to high frequency words). The aim was to find two words of equal length, which are as similar as possible, no matter how you scramble them. We used R packages stringdist and dendextend to accomplish this goal. We computed the cosine similarity between the pixels in each word and every other word of that particular length along with its Zipf score (see Grimmer et al, 2022 for a full description of this methodology). We then selected similar pairs of words based on their cosine values and generated a list of ten words that were semantically related to one word in each pair (e.g., PATRIOTIC, POPULIST, IDEOLOGY, PRIDE, RACIST, HOMELAND, CULTURE, NAZI, FREEDOM, RIGHT-WING), with the paired word serving as the decoy anagram (referred to as the *primed lure*: NLATONALIITS, which is associated with and looks like NATIONALISTS, but the correct answer is INSTALLATION). In our previous experiments, we compared false insight rates among four types of anagrams: the primed lure, the presented target, the primed target, and a random anagram. In the current study, to reduce time requirements and minimise fatigue among participants, we only used the primed target (e.g., AUTRORIATAIHN - AUTHORITARIAN) or the presented target (e.g., TAPRIOITC - PATRIOTIC) anagram types to compare to the primed lure (e.g., NLATONALIITS - INSTALLATION).

We generated a set of 20 new anagrams and word lists using the same procedure as Grimmer et al. (2021) so the anagrams appeared similar, but not too similar, and we conducted a pilot test on 44 subjects to determine which stimuli would produce false insights most reliably. We analysed these data by calculating the proportion of participants who reported a false insight for each anagram and ranked them alongside the mean insight intensity rating given. This analysis (available in full at https://osf.io/6xtvj/) produced twelve sets of words and associated anagrams that were suitable for use in the current study.

The task used in the current study thereby consisted of twelve critical trials. As in Grimmer et al. (2022), at the beginning of each trial, participants were presented with the list of study words in a random order, then asked to unscramble two anagrams—one of which was the deceptive primed lure and the other was a control anagram. After typing their solution, participants were asked whether they experienced an 'insight moment' or not, and if so, rated the intensity of their insight experience on a 12-point Likert-type scale ranging from "not at all strong" to "very strong".

2.2.2. Rational experiential inventory

The Rational-Experiential Inventory (Epstein et al., 1996; Pacini & Epstein, 1999) is a well-validated measure of individual differences in analytic vs intuitive thinking styles with consistently high reliability—Cronbach's alpha > 0.80 (Björklund & Bäckström, 2008; Epstein et al., 1996; Marks et al., 2008; Shirzadifard et al., 2018; Witteman et al., 2009). We predict that people who score higher on rational thinking and lower on experiential thinking will have fewer false insights than those who show the opposite pattern of scores. Scores on these two scales (20 items each) represent the sum of the points assigned to each response on a 5-point Likert-type scale ranging from 1 (definitely not true of myself) to 5 (definitely true of myself).

2.2.3. Cognitive reflection task

As described above, one of the most popular methods of capturing individual differences in analytical thinking is the Cognitive

Reflection Task (Frederick, 2005). This three-item test requires respondents to override their intuitive answers and engage in a rational process to generate the correct answer. Previous research has shown that people who answer more items correctly are less susceptible to fake news, conspiracy beliefs, and are less religious (Pennycook et al., 2015). We predict that people who score higher on the Cognitive Reflection Task will have fewer false insights than those who score lower on the task.

2.2.4. Aberrant salience inventory

The Aberrant Salience Inventory created by Cicero and colleagues (2010) is a reliable measure of aberrant salience that predicts real-life psychotic experiences and produces a Cronbach's alpha of at least 0.89 across several studies (Chun et al., 2020; Cicero et al., 2010; Fernández-León et al., 2019; Golay et al., 2020; Pelizza et al., 2021; Raballo et al., 2019; Scazza et al., 2021). This measure comprises 29 yes/no questions such as "Do you sometimes feel like you are finding the missing piece to a puzzle?" and "Do you ever feel the need to make sense of seemingly random situations or occurrences?". Scores represent the sum of items given a "yes" response. We predict that people who score higher on the Aberrant Salience Inventory will have more false insights than those who score lower on the inventory.

2.2.5. Schizotypy personality questionnaire

Schizotypy is a wide range of experiences and traits that represents people's vulnerability to psychosis (Kwapil et al., 2018). The Schizotypy Personality Questionnaire-Brief (Raine & Benishay, 1995) measures positive, negative, and disorganised features of the schizotypy spectrum, with consistent evidence supporting its validity, and internal reliabilities ranging from 0.75 to 0.83 (Compton et al., 2007, 2009; Fonseca-Pedrero et al., 2009, 2018; Raine & Benishay, 1995). The 22-item scale also asks a series of "yes/no" questions, for example, "Do you often pick up hidden threats or put-downs from what people say or do?" and "People sometimes comment on my unusual mannerisms and habits". This measure is also scored by summing the "yes" responses. We predict that people who score higher on the Schizotypy Personality Questionnaire will have more false insights than those who score lower on the questionnaire.

2.2.6. Jumping to conclusions

The final measure assesses the tendency to jump to conclusions—a reasoning bias commonly found in people with schizophrenia and delusional disorders. Several studies show that people with delusions make decisions based on significantly less information than healthy controls (Dudley et al., 2011; 2016). The tendency to make decisions based on limited evidence is thought to be a key factor underlying the risk of developing psychosis. Jumping to conclusions is most commonly measured with the "beads task" (Dudley et al., 1997). In this task, a participant is shown two jars: one containing 15 red beads and 85 black beads, and the other containing the opposite proportions of red and black beads. The jars are then covered, and the experimenter begins drawing beads out of one jar one by one. The participant watches this until they wish to guess which jar the beads came from. In studies using this paradigm, psychotic patients make their decision after seeing significantly fewer beads than healthy controls. A more difficult version of the task uses a beads ratio of 60:40 and is more sensitive at detecting jumping to conclusions in non-clinical populations (So et al., 2016). In our study, we used a sample of participants with no diagnoses of psychotic disorders, so we used the more sensitive 60:40 version of the beads task. This task uses the traditional single-trial draws to decision measure, which asks participants to indicate which jar they think the beads are from once they feel they have seen enough beads. Thus, in the current experiment, the number of beads seen before making this decision will represent the dependent measure for the Jumping to Conclusions beads task.

2.3. Procedure

Testing took place online through Qualtrics. Participants were first presented with the FIAT, followed by the other measures in a random order. We presented the FIAT first to minimise the effect of participant fatigue, as the latter questionnaires were less cognitively taxing. The experiment took roughly 30 min to complete. Once participants had finished all the tasks they were debriefed and thanked, with the Prolific pool receiving roughly £4.50 as compensation, and the undergraduate pool receiving course credit.

The FIAT task began with a set of written instructions explaining that the participants' task was to study each word list and solve two anagrams before recalling as many words from the list as possible (See Appendix B). Participants all took part in a practice trial before beginning the experiment. Each trial began with the 10 words being presented one at a time on screen, appearing for 1 s each. After the list was presented, the participant was instructed to unscramble the anagram as quickly as they could and to click a button when they had solved it. On each trial, a primed lure anagram was presented, followed by either a presented target or a primed target selected at random. Participants typed their solutions into the text box provided and were then asked whether they experienced an insight moment. Those who responded "yes" then indicated how intense their insight moment was on a scale ranging from 1 to 10. This process was repeated 12 times to complete the task, after which participants completed the Aberrant Salience Inventory (Cicero et al., 2010), the Schizotypy Personality Questionnaire-Brief, the Rational-Experiential Inventory, the Cognitive Reflection Task, and the Jumping to Conclusions beads task.

3. Results

3.1. Descriptives and pre-processing

We first measured the false insights effect by assessing whether our false insights were more common for primed lures than control

anagrams, as in our previous studies. A paired *t*-test revealed that, as expected, primed lures elicited significantly more false insights ($M = 0.47$, $SD = 0.28$) than control anagrams ($M = 0.03$, $SD = 0.08$), $t(199) = 23.39$, $p < .001$, $d = 0.38$). Next, we calculated the split-half reliability of the FIAT by splitting the 12 primed lure trials into two even halves (odd and even numbered trials) and computing each participant's average false insight score for each half of the test. We then computed the Pearson correlation between the two test halves and calculated a Spearman-Brown adjusted coefficient to correct for the halved number of test items (Angoff, 1953). This analysis revealed a reliability coefficient of $\rho' = 0.851$, demonstrating good internal reliability (as with other reliability coefficients, acceptable reliability using Spearman-Brown is considered to be above 0.80).

As in our previous work (Grimmer et al., 2022), the dependent variable was the proportion of primed lure trials on which each participant reported false insights (see Table 1 for means, standard deviations, and bivariate correlations among all measures). Fig. 1 shows the frequency distribution of scores on the FIAT as a proportion of trials with false insights reported. Histograms for the other measures are available in the SOM.

3.2. Preregistered analyses

To test our focal hypothesis that false insights would be positively predicted by scores on the SPQ, ASI, and negatively predicted by scores on the NFC, JTC, and CRT, we ran a multiple regression analysis with the FIAT score—represented as the proportion of primed lure trials for which a false insight was reported—as the criterion and the JTC, CRT, NFC, FI, SPQ, and ASI as predictors. Contrary to our predictions, the model revealed that none of the measures were significant predictors of false insights on the FIAT, $R^2 = -0.01$, $F(6, 193) = 0.71$, $p = .640$. Coefficients and significance levels are presented in Table 2.

3.3. Exploratory analyses

To quantify the extent to which our data support the null hypothesis, we ran a Bayesian correlation between all of our original predictor variables along with our exploratory variables and FIAT scores, which revealed moderate to strong support for the null across all key analyses, the output of which can be seen in Table 3.

Next, we investigated whether false insights were given lower intensity ratings than correct insights. In service of this goal, we considered only participants who had both true and false insights and computed the mean intensity ratings given to true and false insights. We then ran paired *t*-test on these mean ratings, which revealed that false insights were experienced as weaker ($M = 5.86$, $SD = 2.18$) than correct insights ($M = 6.06$, $SD = 2.26$), $t(186) = 2.39$, $d = 0.18$, $p = .018$, though the effect size was small. This result suggests that 'Aha' intensity provides cues about solution quality (Laukkonen et al., 2021), as Danek and Wiley (2017) suggest, and mirrors our earlier findings (Grimmer et al., 2022).

We also checked whether the SPQ-B subscales were individually related to false insights by summing each participant's "yes' responses to the questions measuring cognitive-perceptual, interpersonal, and disorganised schizotypy to calculate their score for each schizotypy dimension. We then ran another correlation analysis between all variables with these subscale scores. However, neither cognitive-perceptual ($r = -0.001$, $p = .985$) nor interpersonal ($r = -0.002$, $p = .974$) schizotypy were related to false insights. Disorganised schizotpy had the largest correlation with false insights, although this relationship was still nonsignificant ($r = -0.100$, $p = .079$). When entered into the regression model, none of these subscale scores were significant predictors of false insights (see SOM for the full results of this analysis).

Finally, we ran two additional sets of exploratory analyses to ensure that our analytic approach was not overlooking relationships that might emerge with different scoring of the false insight intensity data. First, we tested whether the intensities with which the false vs true insights are experienced predict scores on the various personality measures. To test this possibility, we created an intensity difference score, that represented the average intensity with which the true insights were experienced minus the average intensity with which the false insights were experienced. We then estimated a series of regression equations using this difference score to predict each of our personality measures. The difference score did not significantly predict scores on any of these measures (see Table 3 for bivariate correlations). Second, to supplement analyses that look at absolute intensity, we tested whether the variability in the intensity with which people experience false and true insights predicts scores on the individual difference measures. We reasoned that dramatic variation in insight intensity might quantify a tendency towards emotional volatility, which is another trait associated with psychosis

Table 1
Means, standard deviation, and Pearson correlations for all variables.

	M	*SD*	1	2	3	4	5	6	7
1. SPQ	10.79	5.04	–						
2. ASI	15.64	6.92	.42**	–					
3. NFC	70.81	12.11	−.15*	.03	–				
4. FI	68.61	11.66	.02	.29**	.05	–			
5. JTC	3.58	3.19	.15*	−.03	.21**	−.05	–		
6. CRT	0.47	1.21	−.06	−.20**	.28**	−.25**	.25**	–	
7. FIAT	1.39	0.28	−.03	−.03	.03	.10	−.07	.04	–

Note. SPQ = Schizotypy Personality Questionnaire, ASI = Aberrant Salience Inventory, NFC = Need for Cognition, FI = Faith in Intuition, JTC = Jumping to Conclusions, CRT = Cognitive Reflection Task.
*$p < .05$, **$p < .01$, $N = 200$.

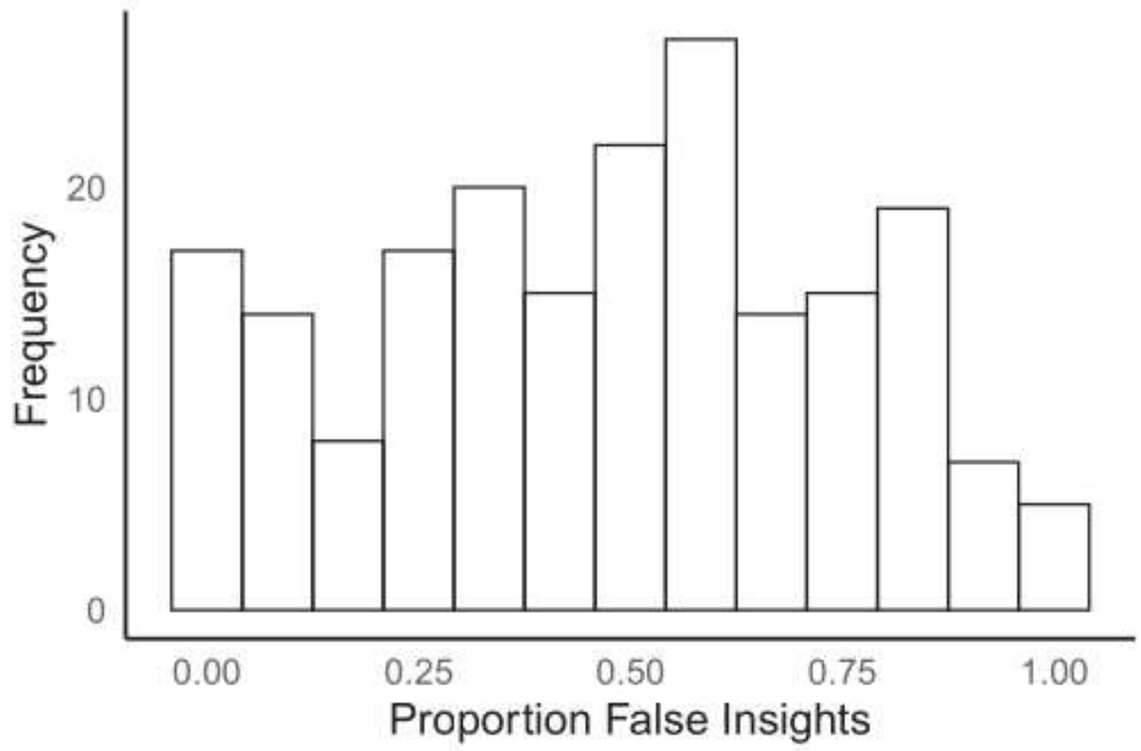

Fig. 1. Histogram of False Insight Rates for Primed Lures Within the Sample. *Note.* $N = 200$.

Table 2
Regression results.

	B	*ß*	*t*	*p*
Constant	.282	.000	.000	.999
	[−.061- .625]	[-.140- .140]		
SPQ	.001	.013	0.156	.877
	[-.008- .010]	[-.149-.175]		
ASI	-.003	-.073	-0.867	.387
	[-.010- .004]	[-.239- .093]		
NFC	.000	.009	0.127	.899
	[-.003- .004]	[-.140- .160]		
JTC	-.006	-.071	-0.933	.352
	[-.019- .007]	[-.222- .079]		
FI	.003	.129	1.686	.093
	[-.001- .007]	[-.022- .280]		
CRT	.016	.073	0.931	.353
	[-.019- .052]	[-.081- .227]		

Note. 95% confidence intervals are reported in square brackets.

proneness (Chapman et al., 2019). Thus, we created a within-participant standard deviation of the intensities of true and false insights and again ran series of regression equations using these variability scores to predict scores on the personality measures. Again, none of these analyses revealed any significant relationships (see SOM for detailed output).

4. Discussion

Who is most prone to having false insights? We investigated this question by testing a new false insight paradigm (FIAT) alongside measures of Need for Cognition, Faith in Intuition, Jumping to Conclusions, Cognitive Reflection, Schizotypy, and Aberrant Salience to determine whether false insights correlate with these measures of thinking style and psychosis proneness. Contrary to our expectations, we found no relationship between people's susceptibility to false insights on the FIAT and individual differences in thinking style and psychosis proneness. A Bayesian analysis also revealed moderate to strong support for the null hypothesis. However, we must consider our findings in the context of the existing literature and theory as well as our methodological limitations.

There are several reasons why we may have failed to find evidence for our hypothesised link between false insights, thinking style, and psychosis proneness. Although the FIAT has good reliability and false insight scores were reasonably normally distributed, our sample may not have been large enough to detect potentially subtle associations between false insights and psychosis proneness or thinking style. Further, our measures of the various individual differences may not have been sensitive enough. Future research could examine more detailed schizotypy measures, for example, such as the as the full version of the Schizotypy Personality Questionnaire (Raine, 1991), the Oxford-Liverpool Inventory of Feelings & Experiences (Mason et al., 1995), the Multidimentional Schizotypy Scale (Kwapil et al., 2018), or the Schizotypy dimensions of the Personality Inventory for the DSM-5 (Ashton et al., 2012).

Another possible explanation for our results is that participants were not sufficiently engaged with the task to answer all questions truthfully. We found the mean draws to decision score on the JTC task in our study to be extremely low, ($M = 3.41$) with 33% of participants deciding after one ball and a score of three balls or less is considered extreme (Hua et al., 2020). However, without face-to-face supervision of the task, it is likely that our participants were disengaged rather than overwhelmingly prone to psychosis, as would normally be indicated by the low JTC scores. Although, participants on Prolific were being paid by the minute and we randomised the

Table 3
Pearson correlations between all measures with associated Bayes factors.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CRT														
SPQ	−.061													
	12.386													
ASI	−.204	.417												
	0.276	**.000**												
NFC	.208	−.149	.030											
	0.231	**1.922**	**16.311**											
FI	−.248	.019	.290	.052										
	0.034	**17.217**	**0.003**	**16.587**										
JTC	.253	.145	−.031	.205	−.053									
	0.026	**2.194**	**16.217**	**0.256**	**13.458**									
FIAT	.043	−.029	−.032	.027	.097	−.073								
	14.854	**16.380**	**16.117**	**16.561**	**7.042**	**10.496**								
Intensity Difference	−.107	.011	.039	−.102	.016	−.022	.126							
	6.018	**16.811**	**14.797**	**6.613**	**16.594**	**16.305**	**4.023**							
False Insight Intensity	−.031	−.111	−.015	.057	.010	−.028	.285	−.257						
	15.665	**5.511**	**16.811**	**12.755**	**16.982**	**15.976**	**0.008**	**0.029**						
True Insight Intensity	−.099	−.089	.022	−.010	−.005	−.066	.240	.312	.838					
	6.828	**8.155**	**16.718**	**17.352**	**17.459**	**11.525**	**0.062**	**0.001**	**0.000**					
Overall Intensity	−.042	−.108	−.001	.075	−.007	−.051	.251	.039	.949	.975				
	14.910	**5.697**	**17.633**	**10.250**	**17.544**	**13.654**	**0.033**	**15.100**	**0.000**	**0.000**				
Intensity SD	.005	−.023	−.061	.078	.042	.032	.107	.159	−.006	.075	.052			
	17.147	**16.353**	**12.171**	**9.780**	**14.589**	**15.625**	**6.008**	**1.601**	**17.361**	**10.276**	**13.566**			
False Insight Intensity SD	.050	.041	−.005	.041	.010	.015	.067	0.096	.095	.149	.158	.825		
	13.350	**14.359**	**16.500**	**14.314**	**16.398**	**16.232**	**11.346**	**7.520**	**7.629**	**2.366**	**1.779**	**0.000**		
True Insight Intensity SD	.014	−.074	−.025	.142	.042	.075	.082	.034	.019	.030	.093	.777	.493	
	16.513	**10.384**	**15.897**	**2.800**	**14.391**	**10.319**	**9.370**	**15.281**	**16.399**	**15.721**	**14.887**	**0.000**	**0.000**	

Note. Bayes' factors (BF01) in bold.

order of the questionnaires, it is possible that some responses were nevertheless compromised.

Although we reasoned that false insights would correlate with thinking style and psychosis proneness in a similar fashion to false memories, there may be important conceptual differences between the false insights elicited by the FIAT and the false memories elicited by the DRM paradigm. Both paradigms use semantic priming to misdirect the brain's associative machinery into producing errors. However, the FIAT also requires carefully manipulated stimuli—anagrams arranged to be visually similar to their intended solution—to elicit the false insight effect (Grimmer et al., 2022). Perhaps this visual element of the FIAT causes the false insights it produces to be incompatible with the purely semantic false memories of the DRM, instead verging on a kind of "illusion".

We must also consider the possibility that false insights for an anagram solution are fundamentally different from the false insights that psychosis sufferers experience, making a laboratory task such as the FIAT an unsuitable instrument to test whether false insights are linked to psychotic symptoms. Put simply, perhaps the false insights that occur for simple problems like anagrams do not share the same origins as false insights carrying delusional ideation. The nature of the disparity between lab-induced 'Aha' moments and real-life 'Aha' moments remains unresolved, and is rarely addressed in the literature (but see Tulver et al., 2021).

There is also some evidence that DRM false memories are not highly related to individual differences in thinking style. Our findings partially overlap with those of Nichols and Loftus (2019), who tested participants on three popular false memory paradigms along with measures of personality, religiosity, anomalous experiences, disengagement from reality, cognitive reflection, and analytic vs intuitive thinking. A handful of weak correlations emerged between performance on the individual difference measures themselves, but few relationships emerged between false memories and any of the individual differences measures, except for a small correlation between DRM false memories and the CRT. Nichols and Loftus (2019) proposed that memory distortion errors are not unique to any certain type of person and that their findings demonstrated the fundamental fallibility of human memory. Although limited to only one measure of false insights, our findings may suggest something similar about the fallibility of the 'Aha' experience as a metacognitive signal of truth (c.f. The Eureka Heuristic: Laukkonen et al., 2020; Laukkonen et al., 2018). Perhaps false insights, much like distortions of memory, reflect a general weakness of human cognition that emerges under certain circumstances and has little to do with individual traits. Such a general flaw in our typically adaptive tendency to believe our 'Aha' moments may necessitate extra caution when appraising the veracity of our ideas.

Research on false insights is a nascent effort. Although we found no relationship between false insights and thinking style or psychosis-proneness—including moderate to strong support in favour of the null hypothesis—further research is needed to make sense of these findings. If the false insight effect reflects a fundamental fault in human cognition, it would be useful to explore their relationship with general cognitive ability. Further, it is worth investigating the FIAT in a similar fashion to how many other researchers have investigated other cognitive illusions, distortions, and errors—through situational manipulations that may play a stronger causal role than individual traits (Ross & Nisbett, 1991). For example, future research could reveal whether the FIAT effect is reduced when participants are aware of the effect or given a warning about the deceptive anagrams. If the FIAT effect is indeed as stable of a distortion as the DRM effect, then we would expect to find a similar resistance to corrective warnings as has been demonstrated across several previous studies (Gallo et al., 1997; McDermott & Roediger, 1998). Thus, there are several reasons why we may have failed to find evidence for our hypothesised link between false insights, thinking style, and psychosis proneness. Investigating the effect of warnings on the FIAT effect could provide valuable evidence on the boundary conditions of experimentally induced false insights.

Author Contributions

HJG, JMT, REL, and BvH conceived of the original idea. HJG and JMT designed and coded the experiments. HJG collected all data and wrote the manuscript with support from BvH, REL, and JMT. AF cleaned the data and assisted HG with the statistical analyses. HJG, JMT, REL, and BvH provided critical feedback and approved the final version of the manuscript.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.concog.2022.103384.

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