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Impact of previous reinforcement on false perceptions for individuals lower and higher in schizotypy traits

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ABSTRACT

Psychotic-like experiences (hallucinations) were investigated in a non-clinical population in a word-recognition experiment. The current study explored the effect of perceived importance (previous reinforcement), and whether this differs in its impact on individuals with lower or higher schizotypy. Participants were assessed psychometrically for their level of schizotypy using the O-LIFE, and were reinforced for choosing wither nouns or verbs. A word recognition task was then presented, during which words or non-words were presented on a fast-moving display was employed. The words could wither be nouns or verbs. Those higher in schizotypy showed greater numbers of false perceptions than those with lower schizotypy, and previous reinforcement history impacted on performance. When words from a previously reinforced class were tested, recognition of words that were present was higher than when the test class was not previously reinforced. Moreover, in conditions where expectancies had been violated, those with higher schizotypy showed greater numbers of false perceptions than those with lower schizotypy scores. Thus, the current findings show situational factors such as previous experience and current context are also important in generating false perceptions.

1. Introduction

Hallucinations can be defined as an experience occurring in the absence of an appropriate stimulus, and can include seeing things, or hearing sounds, that are not present. They are experienced by between 10 and 25 % of individuals without a clinical diagnosis (Maijer, Begemann, Palmen, Leucht, & Sommer, 2018; Marmamula, Sumalini, Reddy, Brahmanandam, & Satgunam, 2020; Tien, 1991), as well as by individuals high in schizophrenic traits (Dudley, Aynsworth, Cheetham, McCarthy-Jones, & Collerton, 2018; Slotema, Bayrak, Linszen, Deen, & Sommer, 2019). Schizotypy describes personality characteristics related to schizophrenia (Bentall, Claridge, & Slade, 1989), and is often measured psychometrically (Mason, Linney, & Claridge, 2005). Higher levels of schizotypy are associated with a bias towards reporting hallucinatory experiences or false perceptions (an event reported in the absence of the event occurring; Bentall & Slade, 1985; Dudley et al., 2018; Jakes & Hemsley, 1986; Tsakanikos & Claridge, 2005).

Tsakanikos and Reed (2005a, 2005b) developed a word detection task to investigate false alarms. Participants detected words among nonwords in a fast-moving array, and those with high schizotypy demonstrated higher rates of false perceptions (reporting words that did not appear) than those with lower levels of schizotypy. This has been taken as an experimental model of hallucinations, and has allowed research that explores the factors modulating the occurrence of false alarms, especially situational differences that may affect the occurrence of false alarms (Reed et al., 2008; Reed, Tshering, & Wahab, 2021; Slotema et al., 2019). Many studies have shown that situations or events that an individual feels important are often those triggering hallucinations (Dudley et al., 2018; Reed & Clarke, 2014; Reed et al., 2021). However, such effects are not only associated with longer-term issues like loneliness (Dudley et al., 2018; Reed et al., 2021) or religiosity (Reed & Clarke, 2014), but also with prior learning or expectancies (Cella, Taylor, & Reed, 2007).

Reed et al. (2008) adapted the above word detection task so that perceptual ambiguity (e.g., the ease of detecting the stimuli due to speed of presentation), and probability of an event (i.e. the relative number of trials on which words or nonwords were presented), could be manipulated. The study found that a group of participants with higher schizotypy scores produced higher numbers of false perceptions, and that both high ambiguity and high probabilities of events increased the levels of false alarms for those with higher schizotypy scores. Likewise, Cella et al. (2007) investigated the effects of expectancies on false alarms by

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generating particular expectancies for the rate of word occurrence in the task trails. Higher expectancies of events (words appearing) resulted in increased levels of false alarms, especially when initial expectancies were violated during test due to higher numbers of actual word stimuli being presented when the expectancy was for low numbers of actual words.

Although previous studies have noted that situations important to the individual are associated with increased hallucinations (Dudley et al., 2018; Reed & Clarke, 2014; Reed et al., 2021), these studies have relied on measuring this importance psychometrically; for example, by assessing loneliness or religiosity. The current study adopted a procedure that allowed importance to be manipulated by reinforcing particular classes of events. It has previously been shown that classes of words, such as concrete or abstract nouns (Randell, Goyal, Saunders, & Reed, 2011), or high or low imagery nouns (Randell, Goyal, Saunders, & Reed, 2012), can be differentially 'hallucinated' in a word detection task. These findings suggested that words classes (nouns, verbs) may be a candidate for manipulation for importance (prior reinforcement).

The current study explored the effect of perceived importance (previous reinforcement), and whether this differs in its impact on individuals with lower or higher schizotypy. Perceived importance was attached to a set of stimuli via a preceding reinforcement task. Participants were required to learn a discrimination between one set of words and another (nouns or verbs), through verbal reinforcement ("yes" or "no"), for selecting stimuli belonging to a particular word class. This training continued until they had selected words from the appropriate set 10 times in a row. The subsequent experimental task involved reporting whether or not words were present in a trail. The test trials contained words from either the reinforced class, or from nonreinforced class, of words. For example, participants could be reinforced for selecting nouns, and then tested comprising either nouns or verbs. It was assumed that those high in schizotypy would show greater numbers of false perceptions than those with lower schizotypy scores, and that the previous reinforcement history would impact on performance. It was hypothesised that when words from a previously reinforced class were tested (i.e. the test used nouns when nouns had previously been reinforced) recognition of words that were present would be higher than when the test class was not previously reinforced (i.e. the test used verbs when nouns had previously been reinforced). Moreover, it was hypothesised that in conditions where expectancies had been violated (the test used nouns when verbs had previously been reinforced) those with higher schizotypy would show greater numbers of false perceptions than those with lower schizotypy scores.

2. Method

2.1. Participants

One hundred and forty (84 female; 47 male; 9 nonbinary) undergraduate students, with a mean age of 20.86 (SD ± 3.39; range 18–31) participated. All participants volunteered for the study, and received participant pool credit. All participants had normal or corrected to normal vision. Ethical approval was given by the University Psychology Department Ethics Committee.

2.2. Apparatus and materials

2.2.1. Oxford-Liverpool Inventory of Feelings and Experiences: Brief Version (O-LIFE(B); Mason et al., 2005)

Oxford-Liverpool Inventory of Feelings and Experiences: Brief Version (O-LIFE(B); Mason et al., 2005) is a 43-item measure of schizotypy, designed to assess psychotic tendencies in a normal population. Items are categorised into four separate components (unusual experiences, 12items; cognitive disorganisation, 11 items; social anhedonia, 10 items; and impulsive non-conformity, 10 items), with respondents providing each item with a yes or a no answer. The items from the unusual experiences, cognitive disorganisation, and impulsive nonconformity subscales can be summed to give an overall score for positive schizotypy, which had an internal reliability of 0.82 in the current study. However, Fonseca-Pedrero, Ortuño-Sierra, Mason, and Muñiz (2015) showed a three-factor model involving unusual experiences, cognitive disorganisation, and impulsive nonconformity provided the best fit to data, meaning it is also prudent to study the influence on performance of the three different positive schizotypy symptoms.

2.2.2. Noun/verb reinforcement task

Laminated white cards (10 cm × 10 cm) with either a noun or a verb word printed them in black, Times New Roman, font 26. The nouns and verbs all had the same occurrence frequency (12; Leech, Rayson, & Wilson, 2001). The mean length of words in both classes was 7 letters. There were 25 noun cards and 25 verb cards.

2.2.3. Experimental word-detection task

A computer-based presentation which presented a series of word recognition trials. Each presentation (trial) comprised a set of four, five-letter strings, each set in an oval shape, one in each of the four corners of the screen. Each trial was presented for 500 ms, and a blank screen was shown for 2 s between each trial. Half the trials contained one word and three letter strings, and half contained just four non-word letter strings. Participants responded "Yes" if one of the oval shapes contained a word. There were two versions of the task: a noun and a verb task. In the noun version of the task, the words were the nouns the cards in the previous phase; in the verb version, the words were the verbs from the cards in previous phase.

2.3. Procedure

The experiment was conducted individually, in a quiet laboratory cubicle. Participants were given an information sheet and consent form. If they consented, they were randomly assigned to one of two experimental groups: one reinforced for selecting verbs; and the other reinforced for selecting nouns. The procedure had phases, always completed in the same order.

2.3.1. Noun/verb reinforcement task

Participants were given the following instructions: "*In this task, you will have to learn, by trial and error, which cards are correct. Point to the card you think is the correct one, and you will be told whether you are correct or not.*". Participants were then presented with pairs of stimuli cards in succession. Each pair comprised one verb and one noun card (randomly chosen from the noun and verb sets). The participant was required to select one of the cards by pointing. The experimenter said 'yes', if the participant selected the correct (reinforced) card, and 'no' if the participant selected the incorrect (non-reinforced) card. When the participant had selected the correct category 10 times consecutively, they moved on to phase two.

2.3.2. Novel selection task

Immediately following from the preceding phase, and without interruption to the task. Participants were presented with 5 pairs of novel stimuli cards (one noun and one verb per pair). The participant selected a card, but did not receive reinforcement. This phase was to ensure that participants had learned to respond to the reinforced class of word, and not to specific words presented. If the participant selected the correct (previously reinforced) word class 5 times consecutively, they moved on to phase three. If they did not, they returned to the Phase 1 training, and were then retested.

2.3.3. Word recognition task

Participants were seated in front of a PC and presented with both the noun or verb versions in counterbalanced order. Half the participants completed the noun version then the verb version, and half completed

the verb version then the noun version. Participants were not informed of the version presented, but received instructions on the monitor that they were free to read for as long as they needed. They then proceed by pressing a keyboard button. Participants were required to answer either 'yes', if they believed a word to be present; or 'no', if they believed a word was not present. There were 50 trials in total in each version of the task: 25 contained a word, and 25 contained no words. There was 1 60s break in between the two versions of the task.

2.3.4. Questionnaire

Participants were the Brief O-LIFE, and had no time limit for completing the questionnaire. Once participants had completed the questionnaire, they were thanked for their time and handed a debriefing sheet.

2.4. Data analysis

To analyse the effect of schizotypy on false perceptions in the various conditions, two analytic strategies were adopted. Firstly, participants were divided into two groups (lower and higher positive schizotypy symptoms), based on the combined unusual experiences (UE), cognitive disorganisation (CD), and impulsive nonconformity (IN) subscales. A three-factor mixed-model analysis of variance (ANOVA), with schizotypy (lower versus higher) and importance pretraining (noun versus verb) as between-subject factors, and test (noun versus verb) as a within-subject factor, was conducted on the correctly and falsely identified words. This approach has the advantage of simplicity, it follows previous practice in the field, and makes no assumptions about the linearity of the relationship between schizotypy and hallucinations. G-Power analysis suggested that, with a medium effect size ($f = 0.25$), and rejection criterion of $p < .05$, for 80 % power, 136 participants would be needed. Secondly, given suggestions by Fonseca-Pedrero et al. (2015), and to preserve the continuous nature of the O-LIFE scales, a regression was used to relate the three positive schizotypy scales to correctly and falsely identified words in each test condition and importance group. This approach preserves the full data set, and allows each sub-scale to be analysed separately, but does make assumptions about the linearity of the relationships. Moreover, a key variable (verb versus noun trials) was within-subject, this complicates the analysis, and necessitates several regressions. G-Power analysis suggested that, with a medium effect size ($f = 0.25$), and rejection criterion of $p < .05$, for 80 % power, 77 participants would be needed, meaning that with 70 participants this analysis was marginally underpowered.

3. Results

The mean score for the positive symptoms of the O-LIFE for the sample was 10.41 (±6.14; range = 0–24). The sample was split at the mean to create a lower scoring positive schizotypy group ($n = 66$; mean = 4.86 ± 2.81; range 0–10), and higher scoring schizotypy group ($n = 74$; mean = 15.36 ± 3.47; range 11–24). Across the two tasks the mean percentage correctly identified words (saying 'yes' when a trial contained a word) was 87.35 % (±6.64; range = 68–99); and the false perception mean was 7.99 % (±4.19; range = 0.25–19.75). There was a significant negative relationship between schizotypy and correctly identified words ($r = -0.317$, $p < .001$), and a significant positive relationship between schizotypy and false alarms ($r = 0.440$, $p < .001$).

Fig. 1 shows the group mean percentage correct for recognising a word was present on trials when a word was present, for the lower and higher schizotypy groups, in each importance condition (noun or verb), for each word recognition test type (noun or verb). Inspection of these data shows that, for the group trained previously to select nouns, both the lower and higher schizotypy groups correctly identified more words at test when those words were nouns than when those words were verbs. There was a slightly greater trend towards this for the higher than the lower schizotypal group. For the groups trained to selected verbs, participants identified more words correctly at test when those words were verbs than when they were nouns. This trend was not so pronounced as for the nouns, and there was less of a difference for the schizotypal groups.

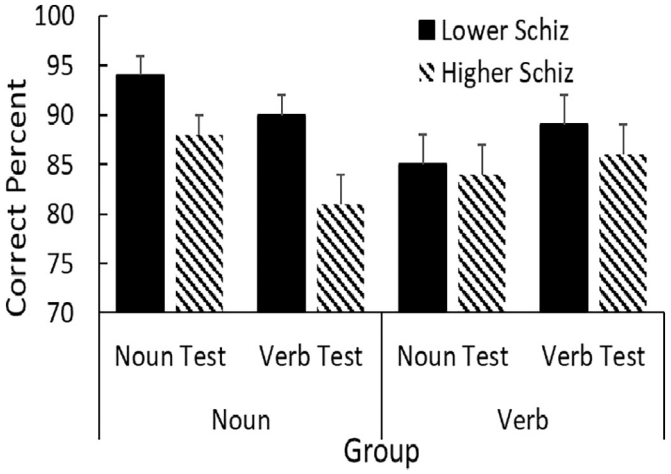

Fig. 1. Group mean percentage correct for recognising a word was present on trials when a word was present, for the lower and higher schizotypy groups, in each importance condition (noun or verb), for each word recognition test type (noun or verb). Error bars = 95 % confidence limits.

A three-factor mixed-model ANOVA (schizotypy, lower versus higher x importance, noun versus verb x test, noun versus verb) was conducted on these data. This analysis revealed significant main effects of schizotypy, $F(1,136) = 20.28$, $p < .001$, $\eta_p^2 = 0.130$ [95 % CI: 0.042: 0.236], importance, $F(1,136) = 5.45$, $p = .021$, $\eta_p^2 = 0.038$ [0.005: 0.119], and interactions between importance and test, $F(1,136) = 26.83$, $p < .001$, $\eta_p^2 = 0.165$ [0.066: 0.275], schizotypy and importance, $F(1,136) = 9.10$, $p = .003$, $\eta_p^2 = 0.063$ [0.007: 0.154], and schizotypy and test, $F(1,136) = 5.56$, $p = .020$, $\eta_p^2 = 0.039$ [0.006: 0.119]. There was no main effect of test, $F(1,136) = 3.68$, $p = .057$, $\eta_p^2 = 0.026$ [0.000: 0.098], and no interaction between all three factors, $F < 1$, $\eta_p^2 = 0.001$ [0.000: 0.001].

Table 1 shows the results of the regression analysis using the UE, CD, and IN O-LIFE subscale scores as predictors, and numbers of correctly identified words on verb trials and noun trials, after training to make verbs or nouns important, as the outcome. As with the dichotomised data, there were significant models for both verb and noun test trials, after nouns had been made important in pretraining, but the effect was larger when nouns were used during the test. With UE related negatively to correct identifications in the verb test, and IN negatively related in the noun test. There was no effect of schizotypy on correctly identified words in either noun or verb trials after verbs had been made important.

Table 1
Regression analyses using unusual experiences (UE), cognitive disorganisation (CD), and impulsive nonconformity (IN) subscales of the O-LIFE as predictors, and numbers of correctly identified words on verb trials and noun trials after training to make verbs or nouns important.

	Noun important		Verb important	
	Verb trials	Noun trials	Verb trials	Noun trials
Regression	$R^2 = 0.176$ $F(3,66) = 4.69^{**}$	$R^2 = 0.257$ $F(3,66) = 7.62^{***}$	$R^2 = 0.063$ $F(3,66) = 1.48$	$R^2 = 0.087$ $F(3,66) = 2.09$
UE	$\beta = -1.346^{*}$	$\beta = -0.468$	$\beta = -0.025$	$\beta = -1.322$
CD	$\beta = 0.537$	$\beta = 0.143$	$\beta = -0.279$	$\beta = -0.345$
IN	$\beta = -0.994$	$\beta = -0.955^{**}$	$\beta = -0.929$	$\beta = 0.964$

* $p < .05$.
** $p < .01$.
*** $p < .001$.

An effect mirroring the smaller effect for these conditions noted with the dichotomised data.

Fig. 2 shows the group mean percentage false perceptions for the lower and higher schizotypy groups, in each importance condition (noun or verb), for each word recognition test type (noun or verb). Inspection of these data shows that, for the group trained previously to select nouns, the higher schizotypy groups falsely claimed a word was present more often during verb tests than noun tests. This was true to a lesser extent for the lower schizotypy group. The groups trained previously to selected verbs, falsely identified words more often during the noun test than during the verb test. Although the two schizotypy groups did this to about the same degree.

A three-factor mixed-model ANOVA (schizotypy x importance x test) revealed a significant main effect of schizotypy, $F(1,136) = 41.35$, $p < .001$, $\eta_p^2 = 0.233$ [0.119: 0.344], and interactions between schizotypy and importance, $F(1,136) = 6.51$, $p = .012$, $\eta_p^2 = 0.046$ [0.002: 0.130], importance and test, $F(1,136) = 8.24$, $p = .005$, $\eta_p^2 = 0.057$ [0.006: 0.146], and schizotypy and test, $F(1,136) = 3.99$, $p = .050$, $\eta_p^2 = 0.029$ [0.000: 0.102]. There was no main effect of importance, $F < 1$, $\eta_p^2 = 0.001$ [0.000: 0.036], or test, $F(1,136) = 1.73$, $p = .190$, $\eta_p^2 = 0.013$ [0.000: 0.072], and no interaction between all three factors, $F < 1$, $\eta_p^2 = 0.004$ [0.000: 0.049].

Table 2 shows the results of the regression analysis using UE, CD, and IN subscales of the O-LIFE as predictors, and numbers of falsely identified words on verb trials and noun trials, after training to make verbs or nouns important, as the outcome. These data show that, after nouns had been made important, there were significant effects of schizotypy on both types of trial, but that this effect was larger on verb trials, and only UE was a significant predictor of false perceptions on verb trials. After verbs had been made important, there were small effects of schizotypy on false perceptions in both noun or verb trials, with only UE related positively to false perceptions on noun trials.

4. Discussion

The current study examined the effect of schizotypy on false perceptions of the presence of words, in the context of seeing words from a class that had previously been made important or not. Those with higher levels of schizotypy (especially those scoring high on unusual experiences) reported more false perceptions than those lower in schizotypy.

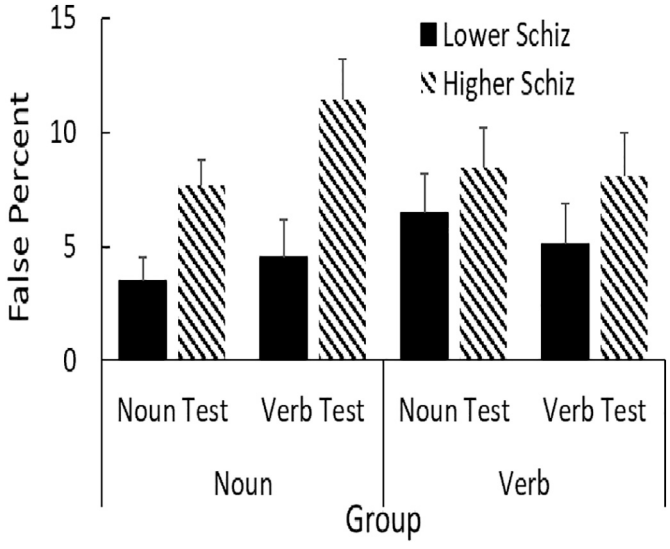

Fig. 2. Group mean percentage false perceptions on trials when a word was present, for the lower and higher schizotypy groups, in each importance condition (noun or verb), for each word recognition test type (noun or verb). Error bars = 95 % confidence limits.

Table 2
Regression analyses using unusual experiences (UE), cognitive disorganisation (CD), and impulsive nonconformity (IN) subscales of the O-LIFE as predictors, and numbers of falsely identified words on verb trials and noun trials after training to make verbs or nouns important.

	Noun important		Verb important	
	Verb trials	Noun trials	Verb trials	Noun trials
Regression	$R^2 = 0.159$ $F(3,66) = 5.36$**	$R^2 = 0.171$ $F(3,66) = 3.54$*	$R^2 = 0.114$ $F(3,66) = 2.83$*	$R^2 = 0.106$ $F(3,66) = 2.60$*
UE	$\beta = 0.807$*	$\beta = 0.487$	$\beta = 0.387$	$\beta = 0.515$*
CD	$\beta = 0.343$	$\beta = 0.234$	$\beta = 0.082$	$\beta = -0.115$
IN	$\beta = -1.348$	$\beta = -0.123$	$\beta = 1.196$	$\beta = -0.228$

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

The previous reinforcement history of the words also impacted on both accurate and false reporting of words. When the class of words tested had previously been reinforced, identification accuracy increased (more so for nouns than verbs). However, when the class of words that was reinforced was tested in the contrasting context (e.g., nouns were reinforced, but verbs were shown at test), false positives increased, especially in those with higher levels of schizotypy. Thus, the current findings show situational factors, such as previous experience, and current context, are both important in generating false perceptions in addition to the level of schizotypy.

That higher levels of schizotypy, and particularly unusual experiences, lead to higher levels of false perceptions is not novel (Tsakanikos & Reed, 2005a, 2005b). However, that this effect increases (albeit with small to medium effect sizes) when words that have been trained to be important (reinforced) in an initial phase are not presented in the test, suggests that expectancies are important in addition to schizotypal traits in predicting when hallucinations will occur – especially when those expectancies are violated (see also Cella et al., 2007). The results are the first to show that this effect can occur when the importance of the item is manipulated, rather than measured (see Dudley et al., 2018; Reed et al., 2021). The current findings, along with others (Cella et al., 2007) suggest that violation of expectancy may be a key feature in the generation of hallucinations for those with high schizotypy, and this deserves further study in order to fully understand the implications for behavior of having high schizotypy traits.

The O-LIFE also provides opportunities examine a number of subscales related to schizotypal traits, and investigation of the relationship between these subscales and the current effects may be informative. The current study did provide some preliminary analyses to this end, and noted the unusual experiences was the implicated construct in relation to false perceptions (see also Tsakanikos & Reed, 2005a, 2005b). However, use of greater numbers of analyses associated with the current statistical analysis increased chances of spurious significance, and that could be an issue. Additionally, the study was designed to allow a dichotomised sample to be analysed, and a larger sample would allow more power for such regression-based analyses.

As with any study, there are several limitations that need to be addressed and noted in the current work. The sample was also reasonably homogenous in nature, and broadening this range of individuals included may be of interest. The inclusion of a control condition, where no previous reinforcement history was given may be useful in future work to see the effect of reinforcement per se on participants with different psychopathological traits. Another limitation may be that some variables (usually related to the schizophrenia spectrum) were not measured (e.g., motivation towards the task requirement), and this could be an example of a factor worth to consider in future studies. Finally, the tendency to find a stronger effect with nouns than verbs may warrant further investigation.

In summary, those higher in schizotypy showed greater numbers of false perceptions than those with lower schizotypy, and previous

reinforcement history impacted on performance. When words from a previously reinforced class were tested, recognition of words that were present was higher than when the test class was not previously reinforced. Moreover, in conditions where expectancies had been violated, those with higher schizotypy showed greater numbers of false perceptions than those with lower schizotypy scores.

CRediT authorship contribution statement

PR was responsible for all aspects of the manuscript.

Data availability

Data will be made available on request.

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