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Enhanced latent inhibition in high schizotypy individuals☆

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ABSTRACT

Latent inhibition refers to a retardation in learning about a stimulus that has been rendered familiar by non-reinforced preexposure, relative to a non-preexposed stimulus. Latent inhibition has been shown to be inversely correlated with schizotypy, and abnormal in people with schizophrenia, but these findings are inconsistent. One potential contributing factor to this inconsistency is that many tasks that purport to measure latent inhibition are confounded by alternative effects that also retard learning and co-vary with schizotypy (e.g. learned irrelevance and conditioned inhibition). Here, two within-participant experiments are reported that measure the effect of familiarity on learning without the confound of these alternative effects. Consistent with some of the clinical literature, a positive association was found between the rate of learning to the familiar, but not the novel, stimulus and the unusual-experiences dimension of schizotypy — implying abnormally persistent latent inhibition in high schizotypy individuals.

1. Introduction

For many years, experimental designs have been translated from the study of animal learning to abnormal psychology in an attempt to understand the symptoms associated with schizophrenia. One of these symptoms is a disruption of attentional function (e.g. Hemsley, 1987; McGhie & Chapman, 1961), and latent inhibition (Hall & Honey, 1989; Lubow, 1973; Lubow & Moore, 1959) has been one of the most common designs used to model abnormal attention in schizophrenia. Here, a stimulus is rendered familiar by mere non-reinforced exposure, before being established as a cue for an outcome. Latent inhibition is observed when participants learn more slowly about the preexposed cue than a non-preexposed control cue during a subsequent test of learning (Lubow & Moore, 1959). Theoretical analyses of latent inhibition have focused upon an attentional explanation — proposing that during preexposure, attention diminishes to the preexposed stimulus so that, subsequently, participants take longer to learn the association between this stimulus and the outcome (Lubow & Gewirtz, 1995; Mackintosh, 1975; Pearce & Hall, 1980) than the non-preexposed cue.

Consistent with the idea that individuals with schizophrenia have a deficit in attention is the observation of an attenuation of latent inhibition in these individuals, which is reflected as the *absence* of slower learning to the preexposed cue. This effect is typically seen in individuals with acute schizophrenia, rather than individuals with chronic schizophrenia (e.g. Baruch, Hemsley, & Gray, 1988a; Gray, Fernandez, Williams, Ruddle, & Snowden, 2002; Gray, Hemsley, & Gray, 1992; Rascle et al., 2001; Vaitl et al., 2002, but see also: Cohen et al., 2004; Swerdlow, Braff, Hartston, Perry, & Geyer, 1996; Williams et al., 1998), and this relationship has been suggested to account for the presence of spurious associations being formed between stimuli in the environment from which unusual thought patterns and positive symptoms may emerge (i.e., hallucinations, delusions) (Kapur, Mizrahi, & Li, 2005; Moran, Owen, Crookes, Al-Urzi, & Reveley, 2008). However, the relationship between attenuated latent inhibition and positive symptomatology has been challenged. Gray et al. (1992) suggested that a reduction in latent inhibition was associated with the acute stage of schizophrenia rather than the positive symptoms per se. When acute and chronic patients with schizophrenia were matched for their level of positive symptoms, an attenuation of latent inhibition was only observed in acute, not chronic patients. Later studies have provided mixed findings: normal latent inhibition has been observed in both acute medicated (Swerdlow et al., 1996) and un-medicated (Williams et al., 1998) patients. More recent studies have shown that acute patients with schizophrenia do show an attenuation of latent inhibition, but that this was correlated with their negative rather than their positive symptoms (Rascle et al., 2001), whereas Cohen et al. (2004) found latent inhibition in schizophrenia patients with high levels of positive symptoms did not differ from that of healthy controls (for a review see: Schmidt-Hansen & Le Pelley, 2012). One possible explanation for the inconsistencies in the literature may be because the effect has an additional pole of expression — an enhanced, or abnormally persistent, latent inhibition effect with the chronic stage of schizophrenia (Weiner, 2003). To the best of our knowledge, only three studies have shown that latent

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inhibition is abnormally persistent in chronic patients with schizophrenia. Rascle et al. (2001), Cohen et al. (2004) and Gal et al. (2009) all report enhanced latent inhibition in patients in a chronic stage of their illness. Although enhanced latent inhibition has been tentatively associated with negative symptoms, this effect appears more specific to illness chronicity (Gal et al., 2009). It thus seems accurate to suggest that schizophrenia is associated with an abnormal *expression* of latent inhibition. Whether an attenuation or enhancement of the effect is observed, depends on the stage of the illness.

As has been noted elsewhere (e.g. Haselgrove & Evans, 2010) comparisons of the cognitive abilities of schizophrenic patients with controls can introduce a number of confounds, notably the medication state of the different groups. To overcome this issue, a dimensional approach can be adopted in which variations in schizotypal personality characteristics are measured in a normal population and correlated with performance on cognitive tasks. A number of studies have now indicated that attentional mechanisms are similarly disrupted in high psychometrically-defined schizotypal individuals and people with schizophrenia (e.g. Baruch, Hemsley, & Gray, 1988b; Evans, Gray, & Snowden, 2007; Granger, Prados, & Young, 2012; Gray et al., 2002; Le Pelley, Schmidt-Hansen, Harris, Lunter, & Morris, 2010; Schmidt-Hansen, Killcross, & Honey, 2009). However, like the schizophrenia literature (e.g. Baruch et al., 1988a; Gray et al., 1992; Rascle et al., 2001), previous studies that have investigated the relationship between schizotypy and latent inhibition have revealed mixed results. Baruch et al. (1988b) were the first to report a relationship between latent inhibition and schizotypy in the normal population; reporting reduced latent inhibition in participants who scored high, but not low (as determined by a median split) on the Psychoticism dimension of the Eysenck psychoticism questionnaire (EPQ; Eysenck & Eysenck, 1975 see also; Allan et al., 1995; Lubow, Ingberg-Sachs, Zalstein-Orda, & Gewirtz, 1992). Similarly, Gray, Snowden, Peoples, Hemsley, & Gray (2003) reported measures of schizotypy to be correlated with reduced latent inhibition, but only when using a between-participant latent inhibition task (see also: Braunstein-Bercovitz & Lubow, 1998; Burch, Hemsley, & Joseph, 2004). However, another between-participants latent inhibition task used by Lipp, Siddle, and Arnold (1994) reported no significant association of the effect with the EPQ (Eysenck & Eysenck, 1975), and an association between latent inhibition and the schizotypal personality questionnaire (Claridge & Broks, 1984) that only approached statistical significance (see also: Lipp & Vaitl, 1992). Furthermore, this trend was due to differences in the non-preexposed control group, with high scorers tending to learn faster than low scorers, rather than the theoretically more interesting, preexposed group. The between-participant tasks used by Baruch et al. (1988b) showed no association between latent inhibition and scores on the Launey–Slade Hallucination Scale (Launay & Slade, 1981). Other studies have shown that, given sufficient preexposure, individuals high in schizotypy can in fact demonstrate a latent *facilitation* effect (De la Casa, Ruiz, & Lubow, 1993) (but see Burch et al., 2004). Therefore, where some authors report a reduction in latent inhibition with higher levels of schizotypy, others do not, and with some authors suggesting a reversal of latent inhibition with schizotypy (see also: De la Casa & Lubow, 2002; Kaplan & Lubow, 2011; Lubow & Kaplan, 1997; Lubow, Kaplan, & De la Casa, 2001; Lubow & Weiner, 2010; Shira & Kaplan, 2009).

More recent studies have tended to employ a within-participant procedure for detecting latent inhibition in which learning about a novel and familiar stimulus is measured in the same participant. Evans et al. (2007), Schmidt-Hansen et al. (2009) and Granger et al. (2012) argue their results support a deficit in latent inhibition, related to the positive dimension of the Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE) (Mason, Claridge, & Jackson, 1995). However, the attenuated latent inhibition effect with unusual experiences reported by Evans et al. and Schmidt-Hansen et al. did not reach the conventional cut-off point for statistical significance. A significant reduction in latent inhibition was attained by Granger et al., but this was a result of an association between the *difference* between the preexposed and non-preexposed stimuli and unusual experiences. This latter observation is problematic, because any correlation between schizotypy and a composite constructed from these two scores does not reveal which of its components is, or is not, contributing to the overall effect. As such it is entirely possible that it is a difference in performance to the *non-preexposed* stimulus, not the *preexposed* stimulus, that contributes to the co-variation of the composite measure with schizotypy. In support of this possibility, Granger et al. did not see any significant relationship between the unusual experiences dimension and learning about the preexposed stimulus alone.

A number of studies of latent inhibition in humans have modified its basic procedure in order to ensure that participants engage with the experiment during preexposure. First, the outcome from the second stage of the experiment might also be included in the first stage of the experiment — unpaired with the cue (e.g. Cohen et al., 2004; De la Casa & Lubow, 2001; Gal et al., 2009; Lubow & De la Casa, 2002; Lubow & Kaplan, 1997; Swerdlow et al., 1996). Second, a secondary, masking, task may be presented concurrently with the preexposed cue. For example, a list of nonsense syllables may be presented and participants required to count the number of times one syllable appears during preexposure (e.g. Baruch et al., 1988a; Gray et al., 1992). The use of either of these modifications undermines the comparability of human latent inhibition to animal models that do not require such procedures to observe latent inhibition (Lubow, 2005). But, more importantly, they also generate procedures that align themselves with other learning phenomena, rather than latent inhibition. For example, by exposing the target outcome during the pre-exposure stage of the experiment in an uncorrelated (or unpaired) fashion with the pre-exposed cue, may result in the establishment of learned irrelevance or conditioned inhibition to the pre-exposed cue; both of these effects are known to retard the acquisition of later learning (e.g.: Baker & Mackintosh, 1977; Rescorla, 1969) and are known to co-vary with schizotypy (Le Pelley, Schmidt-Hansen, et al., 2010; Migo et al., 2006; Schmidt-Hansen et al., 2009).

Evans et al. (2007) have described a within-participant latent inhibition procedure that, they suggest, circumvents the inclusion of a masking-task during preexposure. In this task participants were presented with a series of letters, presented one after the other in the centre of the screen and instructed to press the spacebar as quickly as possible when the letter X was presented. The letter X was either preceded on some trials by a letter (e.g., S) that had been preexposed amidst the filler letter earlier in the experiment or by a letter (e.g., H) that had not been preexposed. This task showed a latent inhibition effect — participants were slower to respond to presentations of X when it was cued by the preexposed letter rather than the non-preexposed letter, and a trend for a reduction in latent inhibition with the positive symptom dimension of schizotypy was observed. As this procedure did not include a concurrent masking task during the preexposure stage of the experiment, it is difficult to explain this result in terms of learned irrelevance. Furthermore, at first blush, it seems difficult to explain this result in terms of conditioned inhibition, as the target outcome was not presented to participants during the pre-exposure phase either. However, as Evans et al. note, an expectation of the target-stimulus was established prior to the preexposure phase through instruction. Thus, conditioned inhibition might be generated because the target outcome was expected to appear (but did not) at a time when the preexposed (but not the non-preexposed) stimulus was presented. Consequently, standard associative models of learning (e.g. Rescorla & Wagner, 1972) predict that during the preexposure stage an inhibitory association will form specifically between the preexposed stimulus and the target X, slowing later learning with this stimulus. Importantly, this slower learning is not a consequence of an attentional mechanism — such one that might generate latent inhibition.

Here we introduce a procedure that examines variations in latent inhibition with schizotypy under conditions where the contribution of conditioned inhibition and learned irrelevance are minimised in order to provide a less ambiguous measure of the impact of learned variations

in attention. However, removing the masking task altogether would result in an experimental paradigm that participants have no requirement to engage in. An alternative strategy then is to keep the masking task in place during preexposure but in such a way as to establish it as task-relevant. The two experiments reported here explored this possibility.

2. Experiment 1

The first aim of Experiment 1 was to create a within-participant latent inhibition task that minimises the possibility of observing conditioned inhibition and learned irrelevance. The second aim was to examine how this task co-varies with schizotypy. Presented here are two variations of a task by Evans et al. (2007; itself modified from that designed by Young et al., 2005). The first version constituted a replication of the task described by Evans et al., to demonstrate latent inhibition, predominantly as a *positive control*. The second version constituted a modification of this task where no expectation of the target was established during the preexposure stage either through instruction or explicit exposure to the target outcome — thus removing the contribution of conditioned inhibition. Instead, as suggested by Evans et al., during the preexposure stage participants were simply asked to count the number of instances of one of the filler letters (M). This manipulation also establishes all of the stimuli in stage 1 as task relevant as participants must process each letter in order to determine whether it is a letter M or not. Consequently, this task is also less amenable to an explanation in terms of learned irrelevance. In the subsequent test stage of both versions of the task, participants continued to be presented with a series of letters, one after the other in the centre of the screen, but were now instructed to make a response as quickly as possible when the letter X appeared. On some occasions the letter X was preceded by a non-preexposed cue, whereas on other trials it was preceded by a cue that had been rendered familiar by being presented during the preexposure stage. Based on the results of Evans et al. it was expected that response-times would be shorter to X when it had been preceded by the non-preexposed, rather than the preexposed cue. We are interested in assessing whether the same effect was evident in the modified version of the task, as this would suggest the operation of a mechanism during stimulus preexposure that is not sensitive to learned irrelevance or conditioned inhibition.

2.1. Method

2.1.1. Participants

Fifty-seven healthy Nottingham University participants and members of the general public (35 males and 22 females) took part, in exchange for course credit or a £4 inconvenience allowance. The age range was 18–54. Twenty-eight participants completed the replicated version of the Evans et al. (2007) LI task ('replicated-task condition'), and twenty-nine completed a modified version of this task ('modified-task condition').

2.1.2. Apparatus

All experimental stimuli appeared on a standard desktop computer running Windows XP, and were programmed using Psychopy (Peirce, 2007; www.psychopy.org). Stimuli were white capital-letters in Arial-font (7 mm × 5 mm; h × w) presented for 1 s each on a computer-screen (28 cm × 35 cm; h × w) with a gray background. The stimulus-letters were S and H, one of the letters served as the preexposed stimulus and the other was the non-preexposed stimulus, counterbalanced across participants. The target was the letter X, with filler-letters D, M, T and V; see Fig. 1.

2.1.3. Procedure

2.1.3.1. Replicated-task condition. The task had two stages: preexposure and test. After reading an information sheet and signing a consent-form, the following instructions were presented to participants on the computer monitor prior to the task:

> "*In this task I want you to watch the sequence of letters appearing on the screen. Your task is to try and predict when a letter 'X' is going to appear. If you think you know when the 'X' will appear then you can press the space bar early in the sequence, that is before the 'X' appears on screen. Alternatively, if you are unable to do this please press the spacebar as quickly as possible when you see the letter 'X.' There may be more than one rule that predicts the 'X.' Please try to be as accurate as you can, but do not worry about making the occasional error. If you understand your task and are ready to start press the spacebar to begin.*"

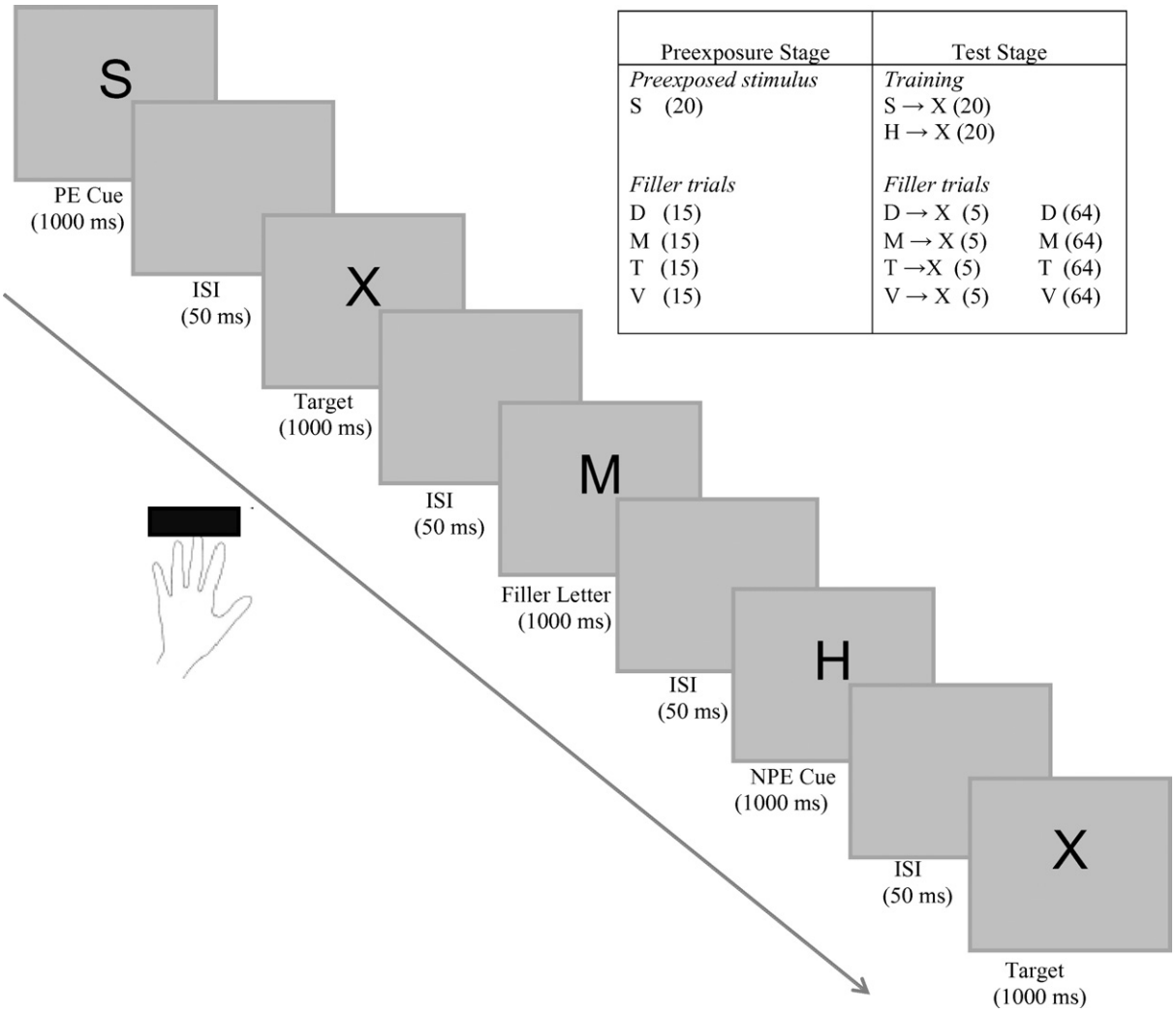
During the preexposure stage the preexposed stimulus was presented 20 times, intermixed in a random order with presentations of filler letters each of which was presented 15 times; each stimulus was presented for 1000 ms separated by a 50 ms inter-stimulus interval. The non-preexposed stimulus and target letter X were not presented during the preexposure stage. The test stage followed the preexposure stage, without interruption. In the test stage, the preexposed stimulus and the non-preexposed stimulus were each presented 20 times followed by a 1000 ms presentation of the target stimulus X. There were also 20 non-cued presentations of X during which the target was preceded by one of the 4 filler letters, each of which preceding the target 5 times. In total there were 64 presentations of the filler letters throughout the test phase. The whole task lasted 7 min. Participants were required to press the space-bar, either when X appeared on screen, or if they could predict when the X would appear as the next letter in the sequence.

2.1.3.2. Modified-task condition. The procedure for the modified version of the task was as described for the replicated version of the Evans et al. (2007) latent inhibition task (Section 2.1.3.1), with the exception that participants received 2 sets of instructions, one set appeared on screen prior to the preexposure stage, instructing the following:

> "*In this task I want you to watch the sequence of letters appearing on the screen. Your task is to count how many times the letter 'M' appears. This task will last about 3 mins. When this task ends, you will be given a new set of instructions. Press any key when you are ready to start the experiment.*"

Thus for the modified-task condition participants were not aware that the target stimulus would appear until after the preexposure phase. A second-set of instructions (identical to those administered at the outset of the replicated-task condition) were then presented prior to the test stage.

A computer-based version of the O-Life (Mason et al., 1995) was administered to assess individual schizotypy. This questionnaire assesses four dimensions of schizotypy. The unusual experiences (UnEx) subscale measures auditory hallucinations, magical thinking and perceptual aberrations reflecting positive symptoms of schizophrenia (e.g., "Have you ever felt you have special, almost magical powers?"). The Introvertive Anhedonia (IntAn) subscale reflects anhedonia (inability to experience pleasure); analogous to the negative symptoms of schizophrenia (e.g., "Do you feel lonely most of the time, even when you're with people"). The Cognitive Disorganisation (CogDis) subscale assesses disruptions in attention/concentration; consistent with the disorganized symptoms of schizophrenia (e.g., "Do you ever feel that your speech is difficult to understand because the words are all mixed up and don't make sense?"). Lastly, Impulsive Nonconformity (ImpNon) measures recklessness, impulsivity and antisocial behavior (e.g., "Do you often have an urge to hit someone?"); similar to the Psychoticism scale of the Eysenck Personality Questionnaire (Eysenck & Eysenck,



Preexposure Stage	Test Stage	
Preexposed stimulus	*Training*	
S (20)	S → X (20)	
	H → X (20)	
Filler trials	*Filler trials*	
D (15)	D → X (5)	D (64)
M (15)	M → X (5)	M (64)
T (15)	T →X (5)	T (64)
V (15)	V → X (5)	V (64)

Fig 1. Experimental design and example stimuli for the test stage of the latent inhibition task. Each trial comprised a 1000 ms presentation of a stimulus separated by an inter-stimulus interval (ISI) of 50 ms. Participants were required to press the spacebar either when the target stimulus 'X' appeared on screen, or before it appeared if they could predict it as the next letter in the sequence. The preexposed (PE) and non-preexposed (NPE) stimuli were counterbalanced across participants. Numbers in parentheses in the insert refer to trial frequencies.

1975).[1] The OLIFE questionnaire has good validity as it maps on to the same multi-dimensional structure as schizophrenia; assessing positive, negative and disorganized symptoms (Mason et al., 1995).

2.1.4. Scoring

Reaction times (RT's) in stage 2 were recorded from the onset of the preexposed and non-preexposed stimulus that preceded the target (X) for each participant. As each stimulus was presented for 1000 ms separated by a 50 ms inter-stimulus interval, participants' RT could range from 0 to 2050 ms. If participants' RT was less than 1050 ms they predicted the X; whereas if their RT was between 1050 and 2050 ms, they responded to the X. Median RTs for responses to the PE stimulus and NPE stimulus were calculated for each participant as it is less biased by extreme values compared to the mean. RT's to both the PE stimulus and NPE stimulus across the 20 test trials were between 1050 and 2050 ms, excluding one NPE trial which had an RT less than 1050 ms for the modified-task version; thus the majority of responses to both stimuli were responses to the X. The scores derived for the four-schizotypy subtypes (complete for Experiment 1 and the subsequent Experiment 2) are presented in Table 2.

2.2. Results and discussion

2.2.1. Latent inhibition

Fig. 2 shows the group mean of individual median reaction times to X across the 20 test trials[2] with the PE and NPE stimuli. Both the replicated-task and the modified-task groups showed faster RTs to the non-preexposed stimulus than the preexposed stimulus — latent inhibition. A 2 (condition: replicated-task, modified-task) × 2 (stimulus: preexposed, non-preexposed) mixed analysis of variance (ANOVA) of individual median reaction times revealed a significant main effect of stimulus $F(1,55) = 16.626$, $p < .001$, partial $\eta^2 = .23$, but no main effect of condition or interaction ($Fs < 1$), suggesting reaction times were similar for participants in both the replicated-task and the modified-task irrespective of target expectation during preexposure. On this basis, and

[1] The adequacy of ImpNon as a valid schizophrenia-like construct has been challenged. It has instead been suggested that this scale is likely to represent a measure of psychopathy and criminality than symptoms observed in schizophrenia. It has also been argued that IntrovAv and the CogDis dimensions are not analogous to the Scale for the Assessment of Negative Symptoms (SANS) in patients with schizophrenia. The UnEx dimension as a measure of positive schizotypy has however been reported to significantly correlate with the Scale for the Assessment of Positive Symptoms (SAPS) in patients with schizophrenia (Cochrane, Petch & Pickering, 2010).

[2] Due to a program limitation, trial order could not be specified; hence the data were collapsed the trials of the test stage. An updated version of the program was used for Experiment 2 which circumvented this issue.

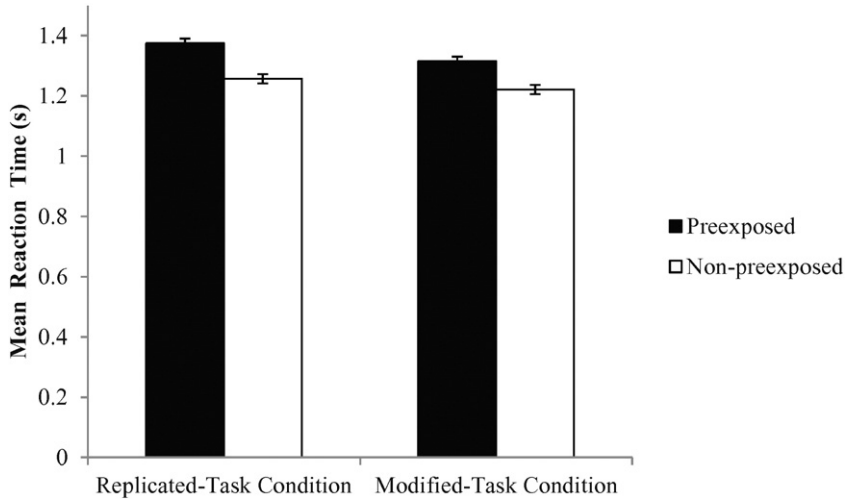


Fig 2. The mean reaction time to the target cued by preexposed stimuli and non-preexposed stimuli for participants in the replicated-task condition and the modified-task conditions in stage 2 of Experiment 1. Error bars are 1 +/− within-subject standard error of the mean (see: Cousineau, 2005).

to increase statistical power, the data were combined from the two test conditions for subsequent analyses.

2.2.2. Latent inhibition and schizotypy

A standard multiple regression analysis was carried out using the four schizotypy subscales taken from the O-Life: UnEx, IntAn, ImpNon and CogDis as the predictor variables, and individual median reaction times to the preexposed and non-preexposed stimuli as the dependent variables. If any of the predictor variables are associated with latent inhibition it would be expected that a relationship would be found with the preexposed stimulus, but not with the control non-preexposed stimulus. When reaction time to the preexposed stimulus was entered as the dependent variable, UnEx was a significant predictor of RTs ($\beta = .36$, $p = .021$), reflecting *slower learning* to the preexposed stimulus with individuals *high* in UnEx, i.e. enhanced latent inhibition. ImpNon was also a significant predictor of reaction time to the PE stimulus ($\beta = -.36$, $p = .014$), reflecting *faster learning* to the preexposed stimulus for individuals *high* in ImpNon, i.e. an attenuation of latent inhibition. Neither of the remaining schizotypy subscales (CogDis and IntAn) were significant predictors of reaction time to the preexposed stimulus ($ps > .05$). When reaction time to the non-preexposed stimulus was entered as the dependent variable, the only significant predictor of reaction time was ImpNon, which again was negatively correlated with RT ($\beta = -.32$, $p = .035$). None of the remaining schizotypy dimensions were significant predictors of reaction to the non-preexposed stimulus ($ps > .05$). All standardized regression coefficients and R^2 values can be seen in Table 1.

The results indicate that individuals high in UnEx are slower to learn the association between the preexposed stimulus and the target than individuals low in UnEx. This, in conjunction with the finding that UnEx was not a significant predictor of reaction time to the non-preexposed stimulus, indicates that individuals high in this subtype are exhibiting an enhancement of latent inhibition. A relationship between ImpNon and RTs to both the preexposed and non-preexposed stimuli was also found, showing that individuals high in ImpNon make faster responses irrespective of whether the stimulus is familiar or novel.

The enhancement of latent inhibition with high UnEx, does not agree with a number of schizotypy studies (Evans et al., 2007; Granger et al., 2012; Schmidt-Hansen et al., 2009). However, the reported attenuation of latent inhibition with high UnEx, failed to reach the conventional level of significance in the studies reported by Evans et al. (2007) and Schmidt-Hansen et al. (2009). Furthermore, it cannot be ruled out that the latent inhibition task employed in each of these studies was not a consequence of alternative learning phenomena instead of latent inhibition, due to the limitations previously described. Before we can draw any further conclusions, however, it is important to acknowledge the possibility that we still might be observing a covariation of schizotypy with learned irrelevance in the current study, as opposed to latent inhibition. Whilst the modified-task condition successfully minimised the contribution of conditioned inhibition, it still included a masking task (count the letter M). Although this procedure — which requires continuous monitoring of the experimental stimuli — establishes a situation in which all of the experimental stimuli are task relevant, it is conceivable that it still establishes learned irrelevance. In this task, participants are required to respond (albeit covertly) to the letter M, rather than any other stimulus. In this sense, then, the preexposed stimulus is irrelevant to the task in hand, thus learned irrelevance may still be the cause of the slower learning to the preexposed stimulus, rather than latent inhibition. As previously discussed, learned irrelevance is an effect which has been shown to influence human learning (Le Pelley & McLaren, 2003) and also co-vary with schizotypy (Le Pelley, Schmidt-Hansen, et al., 2010; Schmidt-Hansen et al., 2009). However, as previously outlined, it would be problematic to remove the masking task altogether as participants would have no requirement to engage in the task during the preexposure stage. Therefore, the aim of Experiment 2 was to design a procedure that examined latent inhibition under conditions where the contribution of *both* learned irrelevance and conditioned inhibition were minimised, but keep the masking task in place during preexposure but in such a way as to establish it as *directly* relevant (as opposed to irrelevant) to the preexposed stimulus. If latent inhibition is still observed under these circumstances, it would permit an evaluation of the effect in terms of models of attention that do

Table 1
Beta-coefficients from the multiple regression analyses of schizotypy subscales (predictor variables), with reaction times to preexposed and non-preexposed stimuli as dependent variables. Summary information includes all participants from the replicated-task and modified-task conditions of Experiment 1.

	Beta-coefficient	
	Preexposed	Non-preexposed
Unusual experiences	**.362***	.188
Cognitive Disorganisation	−.179	−.054
Introvertive Anhedonia	.032	.026
Impulsive Non-conformity	**−.360***	**−.318***
R^2	.164	.092

Note: * $p < .05$; Significant results are in bold.

not emphasise the importance of learned irrelevance (e.g. Esber & Haselgrove, 2011; Pearce & Hall, 1980).

3. Experiment 2

To minimise the contribution of learned irrelevance (as well as conditioned inhibition), the purpose of Experiment 2 was to adjust the parameters of the modified-task condition from Experiment 1. In the preexposure stage, participants were now asked to say out loud each of the letters that appeared on the screen. This manipulation directly establishes all of the stimuli in stage 1 as task relevant as participants must process each letter by reading each of them aloud. Consequently, this version of the task rules out an explanation of any subsequent attenuation of learning to the preexposed stimulus with an appeal to learned irrelevance. Furthermore, as no expectation of the target stimulus (X) is established prior to, or during, preexposure the task is also not amenable to an explanation in terms of conditioned inhibition. The test stage of the task remained the same as the modified-task condition from Experiment 1: participants were required to make a response as quickly as possible when the letter X appeared on screen. We are first interested in assessing whether an effect of stimulus preexposure is still observed under these different circumstances and second, to assess whether the task co-varies with schizotypy. This being the case would suggest a relationship between schizotypy and of stimulus preexposure that goes beyond learned irrelevance.

3.1. Method

3.1.1. Participants

Sixty healthy Nottingham University participants and members of the general public (10 males and 50 females) took part, in exchange for course credit or a £4 inconvenience allowance. The age range was 18–33 years.

3.1.2. Apparatus

The apparatus were the same as described in Experiment 1.

3.1.3. Procedure

The procedure for Experiment 2 was as described in the modified-task condition in Experiment 1 with the exception that the instructions received prior to the preexposure stage asked participants to say aloud each letter that appeared on the screen. A second-set of instructions (identical to those administered at the outset of the test stage of the modified condition from Experiment 1) were presented prior to the test-phase. As per the previous experiments, participants completed the O-Life (Mason et al., 1995) questionnaire. All scoring was performed in the same manner as described in Experiment 1. In keeping with Experiment 1, the majority of RT's to both the PE stimulus and NPE stimulus across the 20 test trials were between 1050 and 2050 ms, excluding 3 NPE trials which had RTs that were less than 1050 ms, indicating that participants were predicting the occurrence of the X on these trials.

3.2. Results and discussion

The scores derived for the four schizotypy subtypes (complete for Experiments 1 and 2) are shown in Table 2. Unpaired *t* test analyses were carried out to assess if the reported schizotypy means differ from the population norms for each subscale. While the means for CogDis and IntAn do not differ significantly from the normative values, the means for UnEx and ImpNon are both significantly lower than the normative values for the modified-task version of Experiment 1, and for Experiment 2. Significant differences are highlighted in bold in Table 2. Previous studies have also obtained mean schizotypy scores that are below Mason et al.'s (1995) normative values, and similar to those reported here (e.g. Evans et al., 2007; Granger et al., 2012; Sellen, Oaksford, & Gray, 2005).

Table 2
Summary information for O-Life scores for the participants in the replicated-task and modified-task conditions of Experiment 1, and all participants from Experiment 2. All values are mean (SD). Population-norms taken from Mason et al. (1995), are also shown (mean (SD)).

	O-Life dimension			
	UnEx	CogDis	IntAn	ImpNon
Experiment 1				
Replicated task	10.1 (6.7)	11.4 (6.3)	6.7 (4.3)	8.2 (3.6)
Modified task	**6.9 (6.3)***	11.2 (6.3)	6.0 (5.1)	**7.8 (3.3)***
Experiment 2	**6.7 (5.4)***	12.3 (6.6)	5.0 (4.1)	**7.1 (3.6)***
Population norm	9.7 (6.7)	11.6 (5.8)	6.1 (4.6)	9.7 (4.3)

Note: * $p < .05$; Significant results that differ from the population norm for these subscales are in bold.

3.2.1. Latent inhibition

Fig. 3 shows the median reaction times to X across the test trials of Experiment 2 (shown in two-trial blocks) with the preexposed and non-preexposed stimuli. It can be seen that reaction times were faster during the non-preexposed than the preexposed stimulus. This impression was confirmed with a 2 (stimulus: non-preexposed, non-preexposed) × 10 (trial block: 1–10) ANOVA of individual reaction times, which revealed a significant main effect of stimulus, $F(1,59) = 25.691$, $p < .001$, partial $\eta^2 = .303$ and a significant main effect of trial number, $F(9,51) = 7.949$, $p < .001$, partial $\eta^2 = .584$, but no significant interaction between these variables, $F < 1$.

In line with both conditions from Experiment 1, Experiment 2 successfully generated an effect of preexposure on reaction times during subsequent learning — latent inhibition. The task presented in Experiment 2 however, produced latent inhibition when the target was not expected during preexposure, and importantly, when using a masking-task that was not irrelevant to stimulus preexposure. These results encourage the suggestion that that an effect of exposure on learning is being observed here — that is to say latent inhibition rather than conditioned inhibition or learned irrelevance.

3.2.2. Latent inhibition and schizotypy

In keeping with Experiment 1, a standard multiple regression was carried out using the four schizotypy subscales from the O-Life (UnEx, IntAn, ImpNon and CogDis) as the predictor variables, and reaction time to the preexposed and non-preexposed stimuli as the dependent variables. Again, when reaction time to the preexposed stimulus was entered as the dependent variable, UnEx was a significant predictor of reaction times to the preexposed stimulus ($\beta = .40$, $p = .021$), reflecting *slower learning* to the preexposed stimulus with individuals *high* in UnEx — replicating the enhanced latent inhibition effect observed in Experiment 1. Unlike Experiment 1, however, ImpNon was not a significant predictor of reaction time to the preexposed

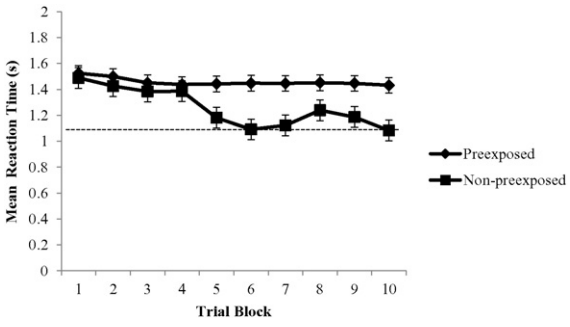


Fig 3. The mean reaction times (sec) to the preexposed and non-preexposed stimuli over the 10 two-trial blocks of stage 2 of Experiment 2. Dotted line indicates the slowest reaction time at which participants can be regarded as anticipating the target (< 1005 ms). Error bars represent 1 +/− within-subjects standard error (see: Cousineau, 2005).

stimulus, nor were the remaining schizotypy subtypes. When median reaction time to the non-preexposed stimulus was entered as the dependent variable, none of the schizotypy subtypes were significant predictors of reaction time to the non-preexposed stimulus ($ps > .05$). Standardized regression coefficients and R^2 values can be seen in Table 3.

In keeping with Experiment 1, the results of Experiment 2 show that individuals high in UnEx are slower to learn the association between the preexposed stimulus and the target than individuals low in UnEx. In both Experiments 1 and 2, we observed facilitation in RTs in individuals high in UnEx that was specific to the preexposed stimulus. These results encourage the suggestion that we are observing an enhancement of latent inhibition, rather than a more general effect of schizotypy on learning to both stimuli. Whilst the findings from both experiments presented here are comparable, the task employed in Experiment 2 is particularly notable as it comprises a relatively 'pure' demonstration of latent inhibition, as it minimises the contribution of both conditioned inhibition and learned irrelevance to stimulus preexposure.

4. General discussion

Two experiments revealed slower learning of a stimulus-target association with a stimulus that had been rendered familiar through prior non-reinforced preexposure than a stimulus that had not — latent inhibition. In both experiments learning about the preexposed, but not the non-preexposed stimulus was related to the unusual experiences dimension of the O-LIFE — revealing an enhancement of latent inhibition in individuals scoring higher on the positive dimension of schizotypy. Experiment 2, in particular, arranged preexposure in a manner that resulted in the subsequent retardation of learning to be explicable in terms of the effects of mere exposure but not the confounding effects of conditioned inhibition or learned irrelevance. This is in contrast to other studies in the latent inhibition literature (e.g. De la Casa & Lubow, 2001, 2002; Evans et al., 2007; Granger et al., 2012; Lubow & De la Casa, 2002; Schmidt-Hansen et al., 2009; Swerdlow et al., 1996), which can be explained in terms of these alternative learning phenomena.

To the best of our knowledge, the current data constitute the first observation of enhanced latent inhibition in sub-clinical high-schizotypy individuals. Three studies (Cohen et al., 2004; Gal et al., 2009; Rascle et al., 2001) have reported enhanced latent inhibition in schizophrenia patients. The first study by Rascle et al. (2001) used a between-participants design in which chronic schizophrenia patients in the preexposed group showed slower learning in comparison to controls, resulting in an enhancement of latent inhibition. The remaining studies, by Cohen et al. (2004) and Gal et al. (2009), like the current study, employed a within-subject manipulation of stimulus familiarity to demonstrate latent inhibition and were able to show an abnormality in learning that was specific to the preexposed stimuli. Both Cohen et al. and Gal et al. showed that latent inhibition enhancement was associated with the negative symptoms experienced by adolescents with schizophrenia. These results are what would be predicted based on Weiner's (2003) model that suggests enhanced latent inhibition is associated with depleted levels of glutamate (see Javiit, 2007; Javiit, 2010), which may be related to the prevalence of negative symptoms. On the other side of the coin, is the reported relationship between the positive symptoms of schizophrenia and attenuated latent inhibition (e.g. Baruch et al., 1988a; Gray et al., 1992, 2002; Rascle et al., 2001; Vaitl et al., 2002). This latter pattern of results is consistent with Gray et al.'s (1991) model for cognitive and neural associates of positive acute schizophrenia symptoms: that a loss of loss of latent inhibition is due to over-activity in the mesolimbic dopaminergic system. At first glance, the results presented here, an enhancement of latent inhibition with the positive UnEx dimension of schizotypy, conflict with these analyses.

There has been considerable disagreement about the relationship between the attenuation of latent inhibition in schizophrenia and positive symptomatology: some authors have found a relationship between latent inhibition and positive symptoms (Baruch et al., 1988a; Gray et al., 1992, 2002; Rascle et al., 2001; Vaitl et al., 2002), others have not (Cohen et al., 2004; Gal et al., 2009; Rascle et al., 2001; Swerdlow et al., 1996; Williams et al., 1998; for a review see: (Schmidt-Hansen & Le Pelley, 2012). In particular, Rascle et al. (2001) reported an attenuation of latent inhibition was associated with low levels of negative symptoms in patients with schizophrenia, rather than with levels of positive symptoms. Whereas Cohen et al. (2004) reported no difference in the magnitude of latent inhibition between high levels of positive symptoms in schizophrenia patients, and healthy controls. These findings, along with the current results, do not support the relationship between latent inhibition attenuation and positive symptomatology. On the other hand, the proposition by Weiner (2003) — that enhanced latent inhibition is related to negative symptoms, refers mainly to chronic patients. However, the findings reported by Cohen et al. and Gal et al. (2009) were able to show an association between enhanced latent inhibition and clinical condition (chronic schizophrenia), but not with the level of negative symptoms per se. The discrepancy between these findings, and the results reported here are possibly due to the nature of the tasks employed by Cohen et al. and Gal et al.; as previously highlighted, these existing tasks confound learned irrelevance with latent inhibition itself. How the refined latent inhibition task reported here covaries with individuals with schizophrenia, is the focus of future research.

One possible shortcoming of employing the multiple regression analysis that we have used in Experiments 1 and 2 is that the observed correlations between UnEx and RT to the non-preexposed stimulus could have been caused by any processes that impact upon the RTs to the preexposed stimulus, including those which also impact on RTs to the non-repexposed stimulus; that is to say, the common variance components affecting RTs to both preexposed and non-preexposed conditions. In order to evaluate this possibility, we pooled the data across Experiments 1 and 2 and conducted a hierarchical multiple regression in which RTs to the non-preexposed stimulus were added in the model in step 1 to act as a covariate, and examined the subsequent relationships between UnEx, CogDis, IntAn and ImpNon (as predictor variables), and RTs to the pre-exposed stimulus (as the dependent variable) in step 2. UnEx remained as a significant predictor of RT to the pre-exposed stimulus in step 2, $\beta = .23$, $t = 2.61$, $p = .01$, as did CogDis now, $\beta = -.18$, $t = 2.07$, $p = .041$. The remaining sub dimensions of the OLIFE were not significant however, $\beta s < -.01$, $ts < 1.2$, $ps > .23$. It therefore appears that the relationship that we observed between schizotypy and RT in the current studies is specific to the pre-exposed stimulus. For the purposes of completeness, we also repeated the previous regression but this time with RTs to the preexposed stimulus entered as a covariate in step 1, and examined the subsequent relationships between UnEx, CogDis, IntAn and ImpNon (as predictor variables), and RTs to the non-preexposed stimulus (as the dependent variable) in step 2. None of the beta coefficients were significant. $\beta s < .03$, $ts < 1.0$, $ps > .39$.

In order to ensure that participants were engaged with the task during the preexposure stage of Experiment 2, a secondary task was employed in which participants were required to repeat, out loud, each stimulus that was presented on the screen. We have argued that immersing preexposure within such a procedure precludes the current

Table 3
Beta-coefficients from the multiple regression analyses of schizotypy subtypes (predictor variables), with reaction times to PE and NPE stimuli as dependent variables.

	Beta-coefficient	
	Preexposed	Non-preexposed
Unusual experiences	**.402***	.238
Cognitive Disorganisation	−.249	.012
Introvertive Anhedonia	.015	−.019
Impulsive Non-conformity	−.160	−.215
R^2	.111	.054

Note: * $p < .05$; Significant results are in bold.

results from being explained in terms of learned irrelevance — as the preexposed stimulus was established as task relevant. This raises the question, then, of whether the current results are a demonstration of latent inhibition or, instead, a circumstance in which establishing a stimulus as task relevant in stage 1 might hinder learning in stage 2 when the same stimulus is established as an explicit cue for a target stimulus. On balance, this possibility seems unlikely. A number of studies have now shown that when a stimulus is established as relevant to the solution of one task, the same stimulus is subsequently better, not worse, than a control stimulus at serving as a cue in a different task (e.g. Bonardi, Graham, Hall, & Mitchell, 2005; Le Pelley, Turnbull, Reimers, & Knipe, 2010). Furthermore, tasks of these sort have been shown to have a negative, not a positive, correlation with schizotypy (e.g. Le Pelley, Schmidt-Hansen, et al., 2010). To the best of our knowledge there is only one demonstration, in humans, of a stimulus being established as task relevant then going on to show a subsequent retardation in learning (Griffiths, Johnson, & Mitchell, 2011). However, this "negative-transfer" effect was demonstrated under circumstances in which the task type was the same between pre-exposure and learning (only the magnitude of the target outcome was changed). Furthermore, to date, there is no evidence of this effect having any relationship with schizotypy.

The two experiments presented here show an effect of schizotypy on learning about a preexposed stimulus using a refined latent inhibition procedure. Both Experiments 1 and 2 show a comparable and novel effect of enhanced latent inhibition in individuals high in UnEx. We advocate the use of the task described in Experiment 2, as this task successfully minimised the contribution of both conditioned inhibition and learned irrelevance on the preexposure effect, and could be a useful tool for assessing attentional dysfunction in schizophrenia, as well as other clinical and sub-clinical populations.

Abbreviations

UnEx	unusual experiences
IntAn	Introvertive Anhedonia
CogDis	Cognitive Disorganisation
ImpNon	impulsive nonconformity
O-Life	Oxford-Liverpool Inventory of Feelings and Experiences
RT	reaction time
	PE Preexposed
	NPE Non-preexposed

Conflict of interest

No conflicts of interest declared.

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