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Research report

Overshadowing depends on cue and reinforcement sensitivity but not schizotypy

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HIGHLIGHTS

- Overshadowing has been reported to be impaired in relation to schizotypy.
- The present study systematically compared overshadowing in two task variants.
- Overshadowing was demonstrated using neutral Lego but not familiar food cues.
- Overshadowing was related to aspects of BIS-BAS but not schizotypy scores.
- The findings suggest that task variant is a determinant of brain substrates.

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ABSTRACT

There is evidence for impaired selective learning mechanisms in individuals high in schizotypy. Overshadowing provides a direct test of selective learning based on cue salience and has previously been reported to be impaired in relation to schizotypy scores. The present study tested for overshadowing using food allergy and Lego construction task variants. Both variants used the same number of conditioned stimulus (CS) cues and the same number of learning trials. CS cues were trained in compound pairs or in isolation and overshadowing was subsequently tested on trials followed by negative versus positive outcomes. Participants also completed the O-LIFE to measure schizotypy and BIS-BAS scales to measure reinforcement sensitivity. Learning was demonstrated for both cue variants; however overshadowing emerged only in the Lego variant and only on the trials followed by the negative outcome. Contrary to expectations, there was no evidence for any relationship between overshadowing and O-LIFE scores. However, there was evidence of a positive relationship between overshadowing and BAS-Drive as well as a negative relationship with BIS-Anxiety, for the trials followed by the positive outcome in the food allergy variant. These results suggest that the development of overshadowing depends on cue and reinforcement sensitivity, but not necessarily on schizotypy.

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1. Introduction

Learning causal relationships between environmental cues and outcomes is a fundamental learning ability. Not only does it enable humans and other animals to anticipate and thus potentially control events likely to occur, selective learning provides a filter on impinging sensory impressions and cues competing for attention. Thus, associative learning is restricted to the best predictors of outcomes, in order to represent the causal structure of the environment.

Latent inhibition (LI) [1] and Kamin blocking (KB) [2] are two-stage procedures whereby learning in stage 1 reduces learning in stage 2, because of the perceived irrelevance of a pre-exposed cue in LI or the redundancy of an additional cue in blocking. Both of these learning phenomena demonstrate how past experience modulates the salience of a stimulus; cues become less salient and therefore less attention is paid to them as a result of previous learning ('acquired' salience, [3]). Over and above differences in salience in consequence of past experience with a cue, inherent physical features (e.g., colour, size, intensity) of a stimulus determine its 'intrinsic' salience [3]. Effects of intrinsic salience on selective learning are demonstrated using overshadowing (OS) procedures [4]. OS describes how learning about one stimulus (A) is reduced when it is paired in compound with a more intense second stimulus (B), as compared to the trials where that same stimulus (A) is presented

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alone. Thus, cues in compound compete based on relative intensity; typically a more intense stimulus acquires associative strength at the expense of that accrued to a less intense stimulus. This effect of cue intensity has been formally incorporated within the attentional parameters of theories of associative learning theory [5–7]: the more salient stimulus captures more attention and thus provides a more effective predictor of the outcome.

Both LI and KB have been found to be dysfunctional in individuals with schizophrenia and this impairment in selectivity of learning has been argued to provide some account of their cognitive symptoms [8–14]. Indeed it has long been suggested that the inability to filter or tune out irrelevant stimuli is a hallmark symptom of schizophrenia [15]. As demonstrated by evidence of disrupted LI and KB in acute patients, they may be 'overlearning' about cues in their environment which have previously been without consequence (LI) or redundant (KB). Deficiencies in LI and/or KB are said to reflect 'hyperassociability', whereby individuals form associations about cues which erroneously appear as salient, consistent with more recent theories proposing that psychosis can be understood in terms of aberrant salience processing [16–18].

In common with LI and KB, in rat studies, OS has been reported to be disrupted by amphetamine, an indirect dopamine agonist known to produce psychotic-like symptoms in non-schizophrenic samples. Following drug administration, the previously salient stimulus no longer overshadowed the less salient in the compound [19,20]. However, there is evidence to suggest that the effective dose is different from that sufficient to disrupt LI [21] and – to date – there are no reports of differences in OS in schizophrenia patients or non-schizophrenic drug-treated human populations and few studies of individual differences within the normal range. Schizophrenia and schizophrenic-like traits represent a complex and heterogeneous phenotype which has been argued to be continuously rather than dichotomously distributed [22–25], but see [26]. Certainly, subclinical signs and symptoms of schizophrenia are observed in otherwise healthy individuals and are part of normal behaviour and experience. The Oxford-Liverpool Inventory of Feelings and Emotions (O-LIFE) [22–24] was devised to measure four dimensions of schizotypy intended to reflect schizophrenic symptoms: unusual experiences (UnExp), cognitive disorganisation (CogDis), introvertive anhedonia (IntAn) and impulsive nonconformity (ImpNo). Many cognitive processes which are dysfunctional in schizophrenia sufferers are similarly dysfunctional in individuals who score highly on schizotypy scales [24,27]. For example, there is good evidence that reduced LI may be attributed to high schizotypy, as measured by a variety of scales [8]. In particular, studies using the O-LIFE show that increased UnExp scores are correlated with reduced LI [28,29]. Reduced LI has also been reported in individuals with increased CogDis and ImpNo scores [29]. Similarly, there is evidence for reduced KB in individuals scoring highly on UnExp and CogDis schizotypy measures [13,30]. Using a geometric associative learning task, Granger, Prados and Young [31] demonstrated attenuated LI and OS in high-schizotypy individuals, specifically relating reduced OS and LI to increased UnExp scores. However, task variant may be a critical factor since a later study which used a different (letter identification) task variant reported the opposite direction of association for LI [32]. OS is a standard control in KB designs. Thus, (individual differences in) the reliability with which OS may be demonstrated is a likely confound of (individual differences in) KB. However, there been relatively little systematic investigation of the brain substrates of OS and how these may compare with those of KB. Moreover, if different mechanisms are responsible for LI, KB and OS, then we would expect OS to show a different relation with schizotypy scores to that reported to date [31].

Learning about environmental cues is also determined by individual sensitivity to reward, non-reward and punishment. Gray's Reinforcement Sensitivity Theory (RST) [33–35] is a biologically determined personality theory which relates the regulation of behaviour and affect to (participants' sensitivity to) motivationally significant environmental stimuli. Carver and White's [36] behavioural inhibition (BIS) and activation system (BAS) scales are the most widely used measure of the original RST constructs. As per the early versions of RST [35], BAS is held to be responsive to all appetitive and rewarding stimuli and to mediate approach behaviour, related to impulsivity as defined by other measures [37]. In more recent developments, the RST revised form [38] posits a third underlying construct, the Fight-Flight-Freeze System (FFFS). FFFS activation results in fear, facilitates the avoidance of aversive stimuli, and subsumes the sensitivity to punishment or non-reward which was previously the role of the BIS. Rather, the BIS is postulated responsible for resolution of goal conflict, for example in situations when both the BAS (approach) and the FFFS (avoidance) have been activated [38]. Based on an earlier study of human associative learning, BAS scores would be predicted to relate to reduced excitatory conditioning [39]. Any such effect would be expected to influence the level of OS.

Accordingly, the present study used two associative learning task variants to examine the relationship between OS performance, schizotypy and BIS-BAS scores. Food allergy paradigms are commonly adopted to provide a Pavlovian type procedure [40]. However, for the majority of participants, a variety of food cues will not be treated as neutral to begin with and moreover, it has been argued that such contingency judgements depend on higher cognitive processes such as reasoning and propositional knowledge [41,42]. Therefore the present study tested OS using both a food allergy paradigm and a novel but analogous task conducted using neutral (Lego) cues, to allow examination of how levels of associative learning and OS seen in the two task variants, conducted under otherwise identical conditions, would be affected by the nature of the cues. In the food task, the CS cues would be easily identifiable and potentially have pre-formed associations likely to facilitate (or limit) learning new associations. However, in the Lego task, the novel CS images would likely have no pre-formed associations and thus any learning would only arise in consequence of the CS-US pairings.

The hypotheses under test were that (1) levels of learning and OS would depend on the nature of the CS and task variant in use; (2) OS would be attenuated in participants with higher O-LIFE scores, specifically on the UnExp sub-scale; and (3) reinforcement sensitivity as measured by the BIS-BAS would relate to levels of associative learning.

2. Method

2.1. Participants

This study used a sample of 66 participants (30 males and 36 females) of mean age (SD; range) 32.6 (15; 20–79) years. All of the participants had completed secondary school, 11 were undergraduates, 41 were postgraduates and 10 were undergoing or had completed some further professional training.

The study was approved by the University of Nottingham School of Psychology Ethics Committee. As compensation for any inconvenience, all participants were entered into a prize draw with the chance to win one of ten £10 gift vouchers.

2.2. Stimuli and materials

2.2.1. Computer-based tasks

Lego cues were provided by photos of coloured blocks and pieces in distinct configurations (Fig. 1). Outcomes were presented on a separate screen as 'Collapsed!' in red text or 'Didn't collapse!' in

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