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The effect of perceptual expectation on repetition suppression to faces is not modulated by variation in autistic traits

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ABSTRACT

There is substantial variation in the magnitude of the repetition suppression (RS) effects across individuals; however the causes of this variation remain unclear. In a recent study, we found that RS in occipitotemporal cortex was negatively related to individual variation in autistic traits in a neurotypical population. Recent proposals have considered autistic behaviours within a Bayesian framework, suggesting that individuals with autism may have 'attenuated priors' (i.e., their perception is less influenced by prior information). Predictive coding represents a neural instantiation of Bayesian inference, and characterises RS as reduction in prediction error between 'top-down' (prior beliefs) and 'bottom-up' (stimulus related) inputs. In accordance with this, evidence shows that RS is greater when repetition of a stimulus is expected relative to when it is unexpected. Here, using an established paradigm which manipulates the probability of stimulus repetition, we investigated the effect of perceptual expectation on RS in a group of neurotypical individuals varying on a measure of autistic traits. We predicted that the magnitude of the perceptual expectation effect would be negatively related to individual differences in autistic traits. We found a significant effect of perceptual expectation on RS in face-selective regions (i.e., greater RS when repetitions were expected relative to unexpected). However, there was no evidence of a relationship between autistic traits and the magnitude of this effect in any face-selective region of interest (ROI). These findings provide a challenge for the proposal that autism spectrum conditions (ASC) may be associated with the attenuated influence of prior information.

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1. Introduction

Repetition of the same stimulus is associated with a reduction in BOLD response, known as fMRI-adaptation or repetition suppression (RS) (Grill-Spector & Malach, 2001; Henson, 2003). As with all physiological measures, there is substantial variation in the magnitude of the RS effect across individuals; however the causes of this variation remain unclear. In a recent study, we found that RS in category-selective regions of occipitotemporal cortex – coding faces, scenes or geometric shapes – showed a negative relationship with individual variation in autistic traits (Ewbank et al., 2014). Variation in autistic traits is proposed to constitute a continuum that extends from the neurotypical population to those with a clinical diagnosis of an autism spectrum condition (ASC) (Baron-Cohen, 1995), a neurodevelopmental condition associated with difficulties in social communication, narrow interests and repetitive behaviours (American Psychiatric Association, 2013).

An understanding of the implications of reduced RS in individuals with high numbers of autistic traits requires an understanding of the neural mechanisms that underlie this effect. A common interpretation is that RS is a 'bottom-up' effect, with reduced BOLD signal reflecting fatigue of a neuronal population responding to a particular stimulus, or a sparser encoding of the repeated stimulus [see Grill-Spector, Henson, & Martin (2006)]. According to predictive coding models – a neural instantiation of Bayesian inference – perception relies on matching top-down prediction signals (prior beliefs) from higher-order areas with sensory feedforward signals. Thus, repetition of a stimulus leads to a reduction in neural activity in a given area because it reflects a decrease in prediction error between stimulus-related and prediction-related inputs (Friston, 2005; Henson, 2003). Consistent with the role of higher-level modulations in RS, we used Dynamic Causal Modelling to show that RS to faces or bodies in occipitotemporal cortex reflects changes in 'top-down' connectivity, with 'higher-level' regions modulating activity in 'lower-level' regions during repetition of the same body/face across changes in size/view (Ewbank, Henson, Rowe, Stoyanova, & Calder, 2013; Ewbank et al., 2011).

Further support for the claim that RS is not a purely a 'bottom-up' mechanism, comes from a study by Summerfield, Trittschuh, Monti, Mesulam, and Egner (2008). They showed that RS to faces in the fusiform face area (FFA) (Kanwisher, McDermott, & Chun, 1997) was greater in blocks in which repetition of a face was more frequent (expected) than in blocks where repetition was less frequent (unexpected). A number of studies have since replicated the finding that RS to faces is modulated by stimulus repetition probability (Kovacs, Kaiser, Kaliukhovich, Vidnyanszky, & Vogels, 2013; Larsson & Smith, 2012; Summerfield, Wyart, Johnen, & de Gardelle, 2011), although the extent to which this effect generalises to non-human primates (Kaliukhovich & Vogels, 2011), or is dependent upon the type of stimulus used, remains unclear (Grotheer & Kovacs, 2014; Kovacs et al., 2013).

If predictive coding models of RS are correct, then individual differences in RS may reflect differences in intrinsic predictive processes. Reduced RS in individuals with high numbers of autistic traits would therefore accord with the proposal that perceptual atypicalities found in ASC can be explained as an attenuated influence of prior knowledge (Mitchell & Ropar, 2004). More recently, Pellicano and Burr (2012) provided a Bayesian formalization of this proposal, suggesting that perceptual atypicalities sometimes found in ASC, such as superior processing of embedded figures and reduced susceptibility to visual illusions (Simmons et al., 2009), might be a consequence of 'attenuated priors', suggesting previous experience has less influence on perception in ASC. Impairments in prediction have also been proposed to underlie other non-social and social symptoms found in autism (Sinha et al., 2014). Similarly, Lawson, Rees, and Friston (2014) recently proposed that many symptoms of autism can be explained within the Bayesian predictive coding framework as aberrant encoding of precision (i.e., an imbalance of the precision ascribed to sensory evidence relative to prior beliefs). Although both proposals emphasise that different aspects of Bayesian inference may be atypical in autism, both 'attenuated priors' and 'aberrant encoding of precision' theories have the same functional consequence for behaviour (i.e., perception is less sensitive to context).

Our previous work, showing reduced RS with increasing autistic traits (Ewbank et al., 2014), used a block-design format, where repetitions were always highly predictable. The aim of the current study was to use the Summerfield et al. (2008) paradigm to manipulate the probability of a repetition of a stimulus, and hence investigate the influence of perceptual expectation on the relationship between RS and autistic traits. We first expected to replicate the finding of greater RS to faces when stimulus repetitions were expected relative to when repetitions were unexpected ("perceptual expectation effect"). Secondly, if diminished RS as a function of autistic traits is a consequence of reduced use of prior information, we predict that the magnitude of the perceptual expectation effect would be negatively related to individual variation in autistic traits.

2. Methods and materials

2.1. Participants

Thirty-two neurotypical volunteers participated in the experiment. The data from three participants were removed due to excessive head movement in the scanner (>3 mm), leaving a total of 29 participants [16 female, all right-handed, aged 19–37 years old, mean age = 26.9 (SD = 6.0)]. Participants were recruited through the MRC Cognition and Brain Sciences Unit's research participation system. All participants had normal or corrected-to-normal vision. None had a history of head injury, neurological or psychiatric conditions (including autism), or was currently on medication affecting the central nervous system. The study was approved by the Cambridge Psychology Research Ethics Committee. All volunteers provided written informed written consent and were paid for participating.

2.2. Stimuli

For the localizer scan and RS experiment, we used a total of 572 black and white photographs of unfamiliar faces with neutral expressions (50% female). Images were obtained from

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