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Fractionation of visual memory: agency detection and its impairment in autism

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Abstract

It is known that the adult visual memory system is fractionable into functionally independent cognitive subsystems, selectively susceptible to brain damage. In addition, there have been hints from studies with individuals with autism that these cognitive subsystems can fractionate developmentally. However, there has been a paucity of systematic investigations. The present study involves the analysis of visual memory of a population of individuals with autism and age- and VIQ-matched comparison individuals. The individuals with autism presented selective impairments in face recognition in comparison to both the age- and VIQ-matched comparison populations. In addition, they were impaired relative to the age-matched comparison group on recognition memory for potential agents (i.e. objects capable of self-propelled motion) whether they were living (cats and horses) or non-living (motorbikes). In contrast, they were selectively *superior* relative to the VIQ-matched comparison group on recognition memory for such objects as topographical stimuli (buildings) and leaves that clearly do not have agency. The data is interpreted in terms of reduced sensitivity to agency cues in individuals with autism and general information processing capacity.

Keywords: Fractionation; Visual memory; Agency detection; Autism

1. Introduction

Studies of patients with acquired neurological lesions have informed us about the degree to which neuro-cognitive systems fractionate in the adult brain. For example, with reference to visual memory, two types of visual memoranda have been shown to be dissociable. Thus, patients have been reported to show selective difficulties in recognising unfamiliar buildings and landmarks [10,42,49,64]. However, despite these impairments, some of these patients have been found to have preserved recognition memory for other visual stimuli, such as unknown faces [34]. Conversely, Maguire and Cipolotti [38] described a patient whose topographical recognition memory for unknown buildings, landscapes and outdoor scenes was preserved whilst her recognition memory for unfamiliar faces was impaired. They propose that this double dissociation indicates that the adult visual memory system is fractionable into functionally independent cognitive subsystems that are selectively susceptible to brain damage.

An interesting, related question is the degree to which neuro-cognitive systems fractionate developmentally; i.e. are there individuals who show appropriate development for some systems in the context of profoundly dysfunctional development in others. Such, and related, questions are beginning to receive considerable attention in the developmental literature [29,37]. Thus, as regards visual memory development, are there individuals who show appropriate development of some visual memory systems in the context of profoundly dysfunctional development in other visual memory systems? Previous work with individuals with autism suggests that this may be the case [12,19,25].

Three studies have investigated visual recognition memory in individuals with autism using a variety of

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memoranda, two concluding that there was no impairment [1,7], the third suggesting that there was [13]. However, the results of this divergent study are difficult to interpret as the memoranda used were verbalisable and, therefore, the poor performance of the individuals with autism could have been due to poor verbal rather than visual memory skills.

Three studies have specifically investigated recognition memory for unfamiliar faces in individuals with autism [12,19,25]. Boucher and Lewis [10] assessed recognition memory for unfamiliar faces and buildings in children with autism. Unfamiliar face recognition was found to be impaired relative to normal peers, non-verbal ability matched controls and verbal ability matched controls. In contrast, recognition of buildings was comparable to that of the comparison populations. This study suggests that individuals with autism may have a selective deficit in visual memory for unfamiliar faces. However, this study failed to include a population of normally developing controls matched for non-verbal mental age. Therefore, it was not possible to conclude whether recognition memory for unfamiliar buildings is preserved in autism or whether children with autism show a comparable decrement in performance relative to normally developing controls in both forms of recognition memory. Ellis et al. [25] found that six out of seven of their subjects with Asperger syndrome (a milder form of autism; [65]) achieved scores on the Recognition Memory test for Unfamiliar Faces [60] that were below the 10th percentile. However, Ellis et al. [25] did not investigate other forms of visual recognition memory in this population so it is possible that they presented with a generalised recognition memory impairment. Cipolotti et al. [19] studied in detail a 29 year old male (PE) with multiple developmental disorders including autism. This individual showed significantly impaired recognition memory for unfamiliar faces in the context of appropriately developed recognition memory for unknown buildings, landscapes and outdoor scenes. However, PE was an individual with multiple developmental disorders thus making generalisation to other individuals with autism difficult.

The data obtained with PE did suggest that recognition memory is developmentally fractionable; the development of visual recognition memory for faces was impaired while that for topographical stimuli was intact. However, it is quite possible that his selective pattern of developmental abnormality was not due to difficulties in the functioning of modular processes but instead due to a differential process of modularisation as a consequence of experience (cf. Ref. [37]). There are suggestions that expertise with faces results in individuals extracting "second-order relational features" that are "distinctive variations of a shared configuration" [16,24]. PE's impairment in unfamiliar face recognition may be due to a lack of interest in faces and thus a failure to develop expertise. Certainly, individuals with autism do show less interest in attending to the faces of other humans [48,65].

An alternative explanation of PE's selective developmental impairment, and the one that Cipolotti et al. [19] favoured, referred to the theory of Mandler and McDonough [40] of concept formation. Mandler and McDonough [40] showed that children from approximately 9 months are able to differentiate their behavioural responses to animate items (objects that move by themselves) and inanimate items (objects that do not move by themselves). Animate items activate a representation of their movement's potential goals [30]. All animate items show these cues of agency. Cipolotti et al. [19] suggested that it is these cues that crucially drive the development of attentive and specially dedicated memory processes. Individuals with autism, like PE, may be less responsive to these cues. Impairment in a system sensitive to such cues might prevent the development of visual recognition memory for faces. Indeed, they noted evidence from human and non-human primates of the presence of regions in the temporal lobe, particularly superior temporal sulcus, that are sensitive to rotational movement, visual motion and biological motion [11,47,50,51]. These regions have also been shown to be sensitive to faces [14,17,18,23]; see, for a review, Ref. [33]. They concluded that PE's selective impairments in visual memory are due to early damage to a neural substrate in the right temporal lobe that is crucial for the development of these systems. Consistent with this possibility are reports of medial temporal lobe abnormalities in individuals with autism [4,20,43].

The aim of the present study was to extend the Cipolotti et al. [19] findings by investigating the following issues. First, will other individuals with autism show selective impairments in face recognition memory? If they do, this would certainly be indicative that some feature of the disorder is a risk factor for the atypical development of this form of recognition memory. Secondly, does the recognition memory impairment extend to other animate objects? The Cipolotti et al. [19] position would predict that it does but an account based around developing expertise would not. The present study investigated these issues with a population of individuals with autism.

2. Method

2.1. Subjects

2.1.1. Autism group

The group of individuals with autism consisted of 15 volunteer participants all with a DSM-IV diagnosis of autism. After initial neuropsychological testing, two of