

# Evidence for Thinking in Pictures as a Cognitive Account of Autism

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## ABSTRACT

In this work, we evaluate the hypothesis that certain individuals on the autism spectrum exhibit a bias towards using visual instead of verbal mental representations.

We first make predictions about how this “Thinking in Pictures” bias might manifest itself in behavior, and then we examine empirical data from several independent behavioral and neuroimaging studies that bear on these predictions.

## HYPOTHESIS

Many introspective accounts by individuals on the autism spectrum suggest the use of mental representations that are predominantly visual instead of verbal (e.g. Grandin, 2006; Hurlburt et al., 1994). Indeed, Joseph et al. (2002) found greater dissociations in individuals on the autism spectrum than in controls between nonverbal (particularly visual) and verbal abilities.

A shallow reading of a “Thinking in Pictures” hypothesis might predict that an individual who thinks visually would show good performance on visual tasks and poor performance on verbal tasks. However, consider the breakdown of cognitive tasks shown in Figure 1. The bulk of psychological evidence on how humans solve tasks has given us  $T_A$  and  $T_B$ , by definition. However, if a typically verbal task (i.e. in  $T_B$ ) happens also to be solvable visually (i.e. lies within  $A \cap T_B$ ), it is possible that an individual who has trouble using verbal representations may be able to develop a compensatory visual strategy for solving that task.

## PREDICTIONS

- 1) Individuals who think in pictures will show decreased levels of performance, relative to typically developing individuals, on tasks that can only be solved verbally (i.e. tasks that lie exclusively in B).
- 2) These individuals will show similar levels of performance and will be using similar (visual) strategies on tasks typically done visually (i.e. tasks that fall into  $T_A$ ).
- 3) These individuals will show similar levels of performance but will be using different (visual instead of verbal) strategies on tasks typically solved verbally but that can be solved visually (i.e. tasks that fall into  $A \cap T_B$ ).



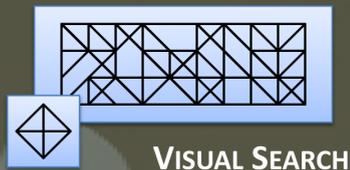
Kana et al. (2006), using an fMRI task in which subjects responded to high or low-imagery sentences, found that individuals with autism activated imagery-related brain regions in both conditions, whereas controls only activated these regions in the high-imagery condition.

Kamio & Toichi (2000) found that individuals with autism performed better on a word completion task when semantic primes were given visually rather than verbally, whereas controls showed no such effect.



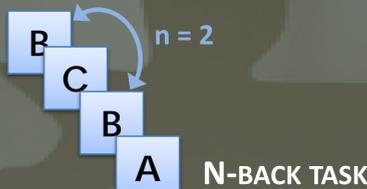
Serial recall for objects is typically done visually at young ages and verbally later on (Hitch et al., 1989). In autism, serial recall abilities are generally intact, though evidence is mixed regarding what encodings are used (Russell et al., 1996; Whitehouse et al., 2006; Williams et al., 2008).

Joseph et al. (2005) found that on a visual self-ordered pointing task, controls benefited from stimuli that were easily labeled versus abstract stimuli, but children with autism performed similarly on both. Also, performance for controls correlated with language ability while performance in the autism group correlated with visual memory, but not vice versa.



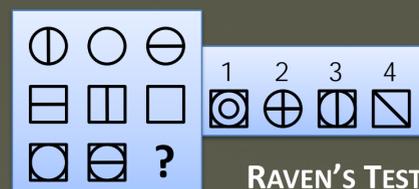
Individuals on the autism spectrum show not only intact but often superior performance on visual search tasks (Jolliffe & Baron-Cohen, 1997; Plaisted et al., 1998; Shah & Frith, 1983).

Ring et al. (2003), using fMRI, found different patterns of brain activation between groups on the embedded figures task, suggesting that the autism group may have been using a different visual strategy (imagery or motion-based) than that used by controls (serial-search-based).



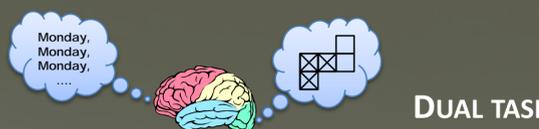
Studies of the n-back task have not shown impairments in accuracy or reaction time for individuals with autism (e.g. Ozonoff & Strayer, 2001), leading some to conclude that verbal working memory in these individuals is intact (Williams et al., 2005).

However, two recent fMRI studies have found significant group differences in brain activation, consistent with the autism group using a visual strategy and controls using a verbal strategy (Koshino et al., 2005; Koshino et al., 2008).



Dawson et al. (2007) found that both children and adults with autism performed better on Raven's Progressive Matrices than on Wechsler tests of intelligence, though controls showed no such discrepancy. Hayashi et al. (2008) found that children with Asperger's actually outperformed controls on the Raven's test.

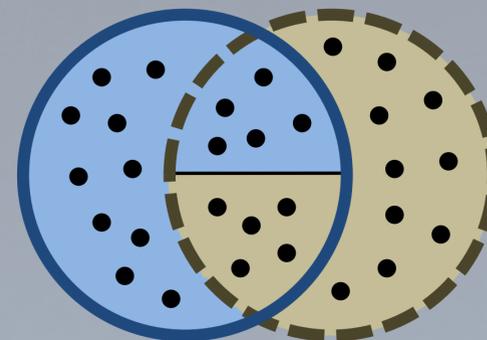
While Raven's is assumed to recruit verbal reasoning processes (Carpenter et al., 1990), both computational (Hunt, 1974) and empirical (DeShon et al., 1995) studies suggest that many Raven's problems can be solved using either visual or verbal strategies.



Garcia-Villamar & Della Sala (2002) looked at digit span in a dual task paradigm, where the secondary task involved visuomotor tracking. Unlike controls, adults with autism showed impaired performance in the dual-task condition. Whitehouse et al. (2006) found the opposite pattern with task switching under articulatory suppression: controls were impaired in the dual-task condition, but the autism group was not.

Both of these studies suggest that individuals with autism and controls used either visual or verbal strategies, respectively, for the primary tasks. However, further studies are needed to look at the effects of both visual and verbal secondary tasks on the same primary task.

## FIGURE 1. BREAKDOWN OF “VISUAL” AND “VERBAL” COGNITIVE TASKS



- A: Tasks that can be done visually
- B: Tasks that can be done verbally
- $T_A$ : Tasks that are typically done visually
- $T_B$ : Tasks that are typically done verbally



## THEORY OF MIND

Happé (1995), reviewing numerous studies, found that performance on theory of mind tasks for individuals with autism correlated with high verbal abilities. Several studies (e.g. Leslie & Thaiss, 1992; Reed & Peterson, 1990) have found that individuals with autism who perform poorly on false belief tasks have intact or superior abilities on tasks involving visual perspective taking or “false image” reasoning, suggesting a dissociation between visual and nonvisual (i.e. theory of mind) versions of the task.

Wellman et al. (2002) found that pictorial “thought bubble” training on false belief tasks helped children with autism pass subsequent tests (although verbal training was not compared). However, this study suggests that proper training may enable some individuals with autism to use novel visual strategies on tasks that are otherwise accessible only verbally.

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