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Research report

# Reduced multisensory facilitation in persons with autism

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ABSTRACT

Although the literature concerning auditory and visual perceptual capabilities in the autism spectrum is growing, our understanding of multisensory integration (MSI) is rather limited. In the present study, we assessed MSI in autism by measuring whether participants benefited from an auditory cue presented in synchrony with the color change of a target during a complex visual search task. The synchronous auditory *pip* typically increases search efficacy (*pip and pop effect*), indicative of the beneficial use of sensory input from both modalities. We found that for conditions without auditory information, autistic participants were better at visual search compared to neurotypical participants. Importantly, search efficiency was increased by the presence of auditory *pip* for neurotypical participants only. The simultaneous occurrence of superior unimodal performance with altered audio–visual integration in autism suggests autonomous sensory processing in this population.



## 1. Introduction

Our perceptual world is made up of events that usually stimulate more than one sense at a given time. The brain must therefore integrate sources of information originating from multiple sensory modalities in order to create a unified and coherent internal representation of our external environment (Stein and Meredith, 1993). This process, referred to as multisensory integration (MSI), ultimately allows us to interact with our surroundings and others in an adaptive manner. It has been previously suggested that atypical MSI may plausibly be the origin for certain characteristic behaviors in autism (Iarocci and McDonald, 2006; Marco et al., 2011), including the avoidance of overstimulating environments and the focus on repetitive sensory attributes (Lovaas et al., 1979). Major cognitive theories in autism such as the Weak Central Coherence (WCC) theory (Frith and Happe, 1994), the temporal binding deficit hypothesis (Brock et al., 2002) and the

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Enhanced Perceptual Functioning theory (Mottron et al., 2006) have evolved from the tenet that autistic (AUT) perception is best defined as being locally-oriented, often resulting in superior performance when a local or detailed processing strategy is advantageous, and a concurrent, inferior performance on tasks necessitating a global or integrative approach (Behrmann et al., 2006; Dakin and Frith, 2005). Such a perceptual approach is consistent with the premise of impaired MSI in autism (Iarocci and McDonald, 2006).

Despite the fact that sensory integration therapies are routinely proposed in rehabilitation (Dawson and Watling, 2000), experimental studies directly investigating MSI abilities in autism are relatively sparse and have yielded equivocal results (Foxe and Molholm, 2009). Most multisensory processing paradigms resulting in MSI deficits in autism have used socially-contingent type stimuli, such as human speech or faces (Magnee et al., 2007, 2008; Silverman et al., 2010; Smith and Bennetto, 2007); but see (Magnee et al., 2009). Importantly, some studies suggested that MSI deficits in autism might actually be limited for more complex “social” stimuli (e.g., speech), with intact integration of simple (non-linguistic, non-social) information (Bebko et al., 2006; Magnee et al., 2008; Mongillo et al., 2008). Therefore, the available literature suggests that MSI impairment in autism may be contingent on the type of information – social or non-social – being integrated across modalities.

In order to investigate if MSI deficit could be observed in autism using non-social stimuli, we assessed MSI within the context of the challenging pip and pop visual search paradigm (Van der Burg et al., 2008). In this task, the presence of an auditory cue (auditory tone or pip) presented in synchrony with the color change of a target during a complex visual search task typically results in more efficient search performance. The synchronous *pip* makes the target *pop*-out from its complex visual environment, suggesting the beneficial and spontaneous use of multiple sources of sensory information when available. This task is particularly relevant for investigating MSI in autism since this effect has proven to be purely multisensory (the visual cue alone cannot trigger the effect), is largely automatic (the effect is *stimulus-driven* and mainly independent of higher-level goals or expectations), and is believed to isolate integration occurring at lower-levels (non-social) within the sensory processing hierarchy (Van der Burg et al., 2008, 2011).

## 2. Methods

### 2.1. Subjects

Nineteen participants (16 M) diagnosed with AUT disorder (AUT – referred to as autism throughout) and 20 typically developing (TD) participants (19 M) were recruited from the database of the Rivière-des-Prairies Hospital (Montréal, Canada). The data of three participants with AUT disorder and one TD participant were not included in the analysis due to the impossibility of the subject to do the task adequately (less than 65% of correct responses when all the conditions were mixed). The resulting groups were closely matched in terms of gender (AUT: 15 M/1 F; TD: 19 M/0 F), age (AUT: mean age 24.5 years ± 5; range 14–31 years; TD: mean age 21 years ± 4; range 14–27 years), and Wechsler IQ [(full-scale = AUT: 102 ± 15; TD: 110 ± 9); (Performance = AUT: 101 ± 13; TD: 108 ± 10); (Verbal = AUT: 102 ± 17; TD: 111 ± 12)]. AUT Disorder was defined using stringent Diagnostic and Statistical Manual of Mental Disorders, 4th edition text revision diagnostic criteria, as operationalized by the combination of Autism Diagnostic Interview – Revised (ADI-R) (Lord et al., 1994) and the Autism Diagnostic Observation Schedule – Generic (ADOS-G) (Lord et al., 2000) algorithms. All AUT participants experienced language delay (acquisition of the first words or sentences ≥36 months) or atypical language during development (echolalia, stereotypic sentences, pronoun inversion, etc.), therefore representing a clinically homogenous group representative of prototypical autism. Control participants and their first-degree relatives were screened with a questionnaire for any history of neurological or psychiatric disorders. All participants had normal or corrected-to-normal vision as evaluated by a Snellen chart prior the beginning of the experiment. The ethics boards of both the Rivière-des-Prairies Hospital and the University of Montreal (where testing took place) approved the study. Written informed consent was obtained for all of the participants, who received financial compensation for their participation in the study.

### 2.2. Apparatus, stimuli and procedure

Stimulus presentation and data collection were controlled by an Hewlett–Packard DC5800 computer equipped with a built in ATI Radeon 3100 graphic card and a C-Media PCI CMI8738 sound card. Visual stimuli were presented on a 17-inch color CRT monitor refreshed at rate of 75 cycles/sec (Hz) with a screen resolution of 1024 × 768 pixels. Stimuli generation and animation were controlled with Matlab R2009b (Mathworks Inc., Sherborn, MA, USA). Participants sat in a silent and dimly lit room with their head positioned on a chinrest 59 cm away from the monitor. They were instructed to search for a horizontal or vertical line segment (target) among displays of 24, 36 or 48 oblique line segments (length .57° visual angle) of various orientations (distracters) (see Fig. 1A). The orientation of each distracter deviated randomly by either plus or minus 22.5° from horizontal or vertical; the target was always either horizontally- or vertically-oriented. At random intervals (on average once every 100 msec), a random number of items changed color between red and green with the constraint that the color of the target always changed alone, never coinciding with the color change of any distracter. The target and distracter line segments were presented on a black background. On average, target color changes occurred once every nine items color changes (on average once every 900 msec). Therefore, the more frequent distracter color changes around the target resulted in a complex and difficult visual search. A more extended description of the stimuli and procedure can be found in the methods of the Experiment 1 of the original paper of Van der Burg et al. (2008). A demonstration can be found on http://www.psy.vu.nl/pippop.

Two task conditions were presented: (1) a tone-present condition, in which the visual target change of color was accompanied by a short sound or *pip*, and (2) a tone-absent condition, in which no sound was presented during the task.