Evidence for Deficits in Mirror Neuron Function, Multisensory Integration, and Sound-form Symbolism in Autism Spectrum Disorders

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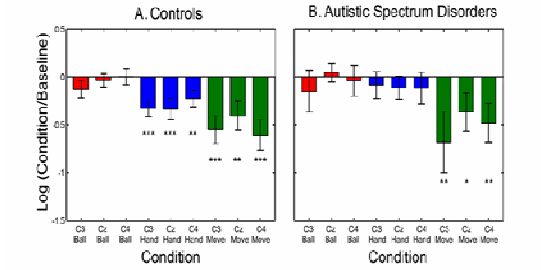
Introduction

Individuals with autism often show both low-level sensorimotor impairments and higher-level cognitive-social impairments. **We have previously suggest that a failure of multisensory integration (MSI) systems such as the mirror neuron system (MNS) may be the underlying cause of some of the deficits seen in Autism Spectrum Disorders. We have reported evidence for impairments in the MNS in individuals with autism[1,2].** The MNS, thought to play a critical role in self-other mapping and skills such as imitation, theory of mind, empathy, and language is, at its most basic level, a multisensory system, **converting sensory stimuli into motor representations. Consistent with this, we report deficits in another task thought to tap into MSI. The bouba-kiki effect[3]** is produced when subjects are asked to name nonsense shapes. For example, if given an amoeboid shape and a jagged shape and asked to name one "bouba" and the other "kiki," 95% of the general population will name the amoeboid shape bouba and the jagged shape kiki. This is presumably because of mirror neuron-like multisensory systems that integrate the visual shape with sounds (sound-form symbolism)[4]. Surprisingly, only 20% of individuals with autism showed this effect. We suggest that the MNS may be involved in MSI in the linguistic domain including the boub-kiki effect and metaphors, which would explain their deficits in both tasks. **These findings suggest that MSI deficits may lie at the core of the seemingly unrelated behavioral impairments that characterize ASD.**

What Causes Autism?

* Our lab has provided EEG evidence that a deficit in the mirror neuron system (MNS) may underlie autism[1,2].
* Mirror neuron-like ability may underlie not only sensori-motor transformation, but also multisensory integration as in the bouba-kiki effect; matching nonsense shapes to sounds.
* Consistent with this, children with autism perform poorly on this task

Previous Findings



Mu suppression in control and ASD participants. Bars represent the mean log ratio of power in the mu frequency (8-13 Hz) during the watching balls condition (light gray), watching hand movement condition (medium gray) and moving own hand condition (dark gray), over the power in the baseline condition for scalp locations C3, CZ and C4 for typically developing individuals (a) and individuals with ASD (b). Error bars represent the standard error of the mean. For all values, a mean log ratio greater than zero indicates mu enhancement; a mean log ratio less than zero indicates mu suppression. Significant suppression is indicated by asterisks, * p< .05, ** p< .01, *** p< .005. The lack of mu suppression in the hand condition in individuals with ASD indicates dysfunction in the mirror neuron system in these individuals.

Task

MSI Responses **Stimuli**

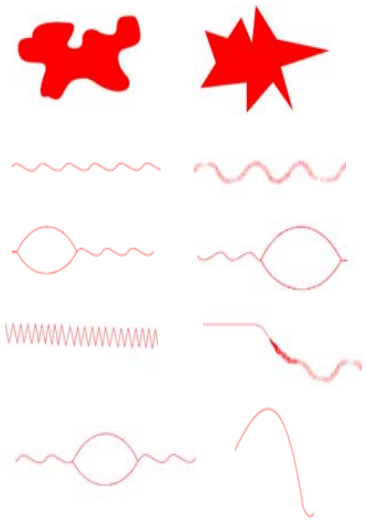
Bouba / Kiki

Mmmm / Shhhh

Ohmmm / Mmmao

Rrrrr / Eeeeshhh

Wow / Bloop



Results

Shape Pair	Autism (% MSI response)	Typically Developing (% MSI response)
Bouba/Kiki	60%	90%
Shhhh/mmmm	60%	90%
Ohmmm/Mmmao	80%	80%
Eeshhh/Rrrr	40%	100%
Wow/Bloop	40%	60%

* Only one individual (out of 5 tested) with Autism performed above 60% on this task.

* Only one typically developing individual performed below 80% on this task

Discussion

Results of this study provide the first empirical evidence that individuals with Autism show an overall impairment in the bouba/kiki task. While 9 out of 10 typically-developing children performed above 80% on this task and appropriately matched the visual shape with its auditory match, only 20% of kids with autism were able to perform above 60% (in a task where 50% is chance). We believe that this deficit may be mediated by the same underlying impairment that leads to deficits in the mirror neuron system as well as behavioral deficits in imitation, theory of mind, and empathy. Specifically, each of these impairments may be mediated by a underlying deficit in multisensory integration, having shared representations across modalities.

The two regions that have been identified to contain mirror-like responses in the human brain are the inferior frontal gyrus and the inferior parietal lobule[5]. There is evidence for a dysfunction in the MNS of the inferior frontal gyrus in individuals with ASD[2,6]. Additionally, this region (Broca's area) is thought to play a large role in language. Making the mirror neuron system a candidate neural mechanism mediating the bouba-kiki effect as well as other multisensory skills. **Additionally, another relevant population that appears to have difficulty with this task is individuals with Gerstmann's Syndrome who have damage to the inferior parietal lobule[7].** These two findings mutually support the role of mirror neuron systems in multisensory integration skills.

This multisensory-integration/mirror neuron hypothesis of autism is a novel hypothesis that goes beyond identifying a neural or behavioral abnormality in individuals with ASD. This hypothesis provides a functional neural mechanism whose multisensory properties make it an ideal candidate for the underlying basis of autism.

References

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