Non-visual variant of RHI reveals monochannel preference in Autism Spectrum Conditions

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AIMS

Previous evidence highlighted an impaired processing of multimodal information in Autism Spectrum Conditions (ASC)[1]. In particular, individuals with ASC have been demonstrated to be less susceptible to multisensory illusions, such as Rubber Hand Illusion (RHI)[2,3]. Here, we aimed at investigating whether a monochannel variant of the RHI[4] is more effective in inducing an illusory feeling of ownership over the fake hand in ASC, thus allowing to describe an efficient integration of multiple sensory sources when they involve the same channel.

Materials and methods

→ *Experimental paradigm*

A total of 102 right-handed participants (age range: 9-16; 51 ASC and 51 TD) took part in the study. Twenty-five children with ASC (6 females; age: 13.12±2.44; IQ: 114.50±3.86) and twenty-five controls with typical development (TD) (10 females; age:12.36±1.68; IQ:114.93±3.42) underwent the visual-tactile RHI. A different sample of twenty-six children with ASC (6 females; age: 13±2.47; IQ: 114.50±3.43) and twenty-six TD controls (6 females; age:12.13±1.65; IQ: 113.37±2.58) were enrolled in the tacto-tactile RHI.

In the **visual-tactile RHI** (Figure 1 - left panel), a black towel covered the subject's shoulders and the proximal end of both the subject's real hand and the rubber hand, so that the rubber hand was perceived as an extension of the participant's own arm. A box was placed in front of the subject's chest (about 15 cm far) and set in order to have the rubber hand, placed in the half of the box open to the view, aligned with the participant's shoulder. The participant's left arm was placed within the part of the box hidden from view, with the palm facing down and the fingers stretched out. In the other half of the box, open to the view, a left rubber hand was placed (at a distance of approximately 25 cm from the own hand), exactly where the participant's hand has to be. The hand stroking (Synchronous or Asynchronous) was delivered for 180 s by the experimenter's hand on the index finger from the knuckle to the fingertip, at an approximate frequency of 1 Hz. Asynchronous stroking of the own hand and the rubber hand was utilized as a control condition, in which strokes were delivered spatially and temporally out of phase between the two hands. The order of synchronous and asynchronous stroking were counterbalanced between participants.

In the **tacto-tactile RHI** (Figure 1 – right panel), the participants were blindfolded, and their left hand was placed on a pre-defined position on the table, externally misaligned with respect to the participants' shoulder, and a left rubber hand was placed 15 cm (distance between the two index fingers) to the right of the participant's left hand. The experimenter held the participant's right hand and used the participant's right index finger to stroke the rubber hand on its index finger. The experimenter stroked with his index finger the index finger (i.e., from the knuckle to the fingertip) of the participant's left hand to create the corresponding tactile input. We manipulated the synchrony between the touch applied to the participant's left hand and the rubber hand, as previously done for the visual–tactile RHI. The touch was applied either synchronously or asynchronously for 180 s. As for visual-tactile RHI, The order of synchronous and asynchronous stroking were counterbalanced between participants.

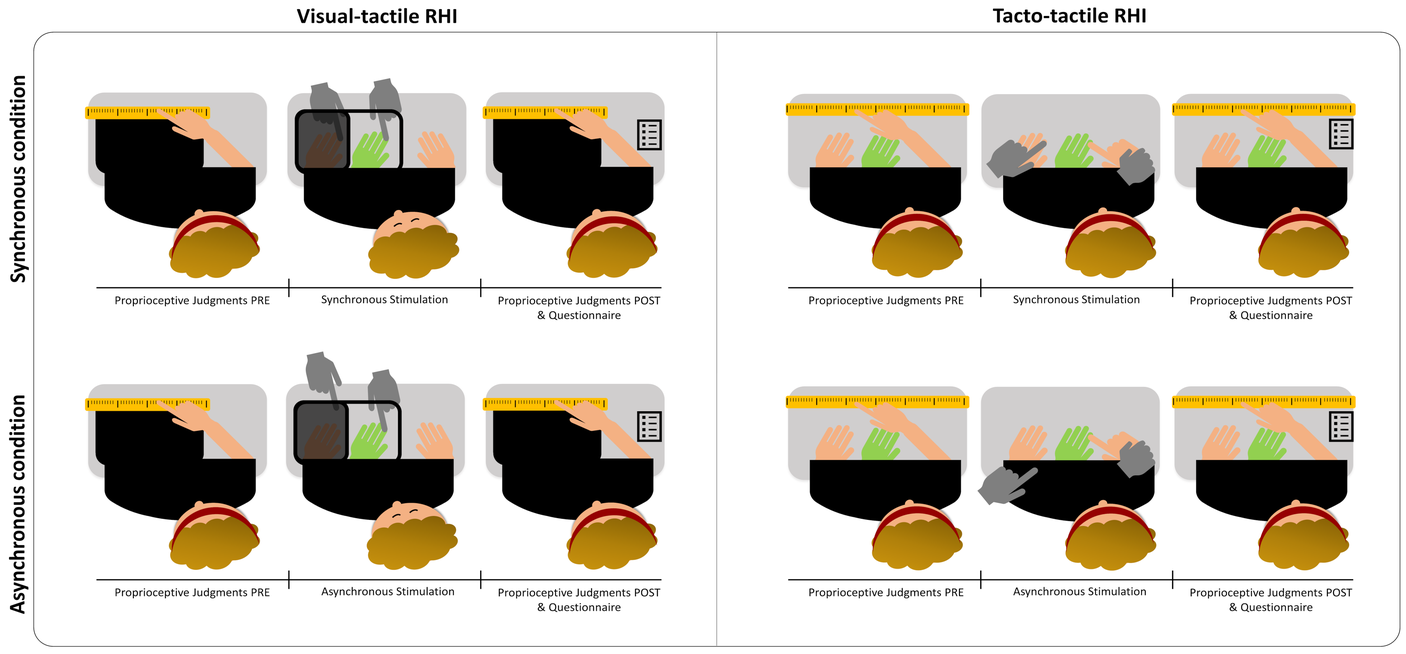
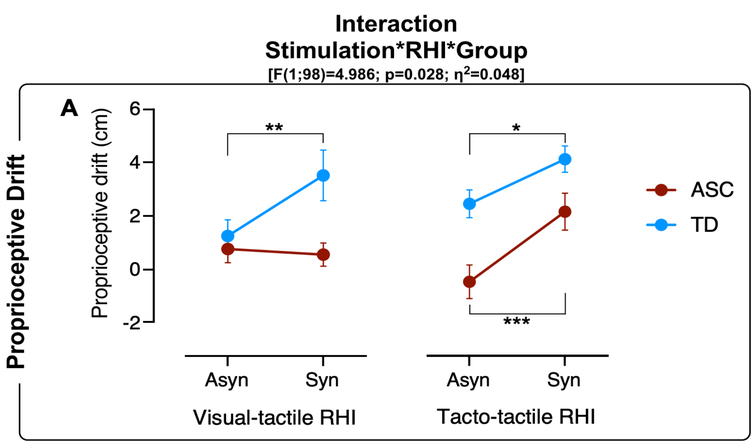


Figure 1

Data analysis

To evaluate the susceptibility to RHI, we collected two measures (i.e., proprioceptive drift and embodiment questionnaire). As objective measure, the proprioceptive drift was calculated as the difference between the perceived position of the index finger collected before (i.e., 6 trials of pre-test baseline proprioceptive judgments) and after (i.e., 6 trials of post-test proprioceptive judgments) the RHI stroking period. As subjective measure, the embodiment questionnaire consisted of three selected items adapted from previous studies[4,5]. In questionnaire, participants were asked to evaluate the vividness of their experience of ownership over the stimulated hand using a printed 7- points Likert scale, by rating their agreement/disagreement with each item (–3 = strong disagreement; +3 = strong agreement; 0 = neither agreement nor disagreement) presented in random order to avoid learning effects. The embodiment questionnaire was analyzed as scores calculated as the mean value of the three items.
Proprioceptive Drift values and Embodiment questionnaire scores were entered separately in two 2*2*2 repeated measures ANOVAs with Stimulation (two levels: synchronous; asynchronous) as within-subject factor, and RHI (two levels: visual-tactile group; tacto-tactile group) and Group (two levels: ASC group; TD group) as between-subject factors. Post hoc comparisons were performed by means of Duncan's test.

Results



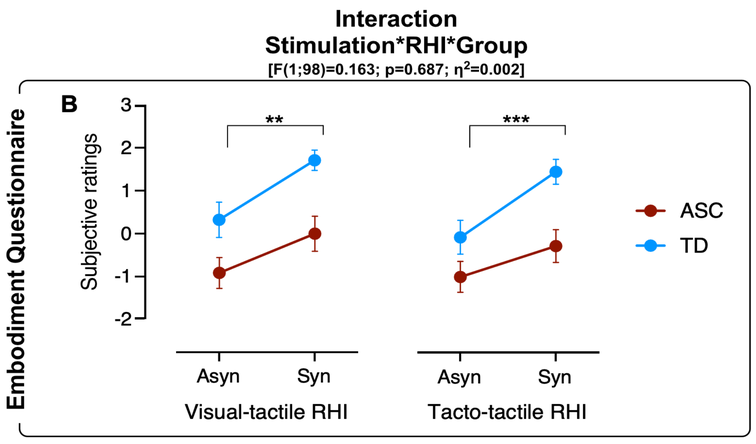


Figure 2

Proprioceptive Drift

The 2*2*2 ANOVA run on Proprioceptive Drift showed a main effect of Stimulation [F(1;98)=15.048; p<0.001; η^2=0.148], with a greater shift towards the rubber hand after synchronous (mean±SEM:2.58±0.36cm) than after asynchronous stimulation (mean±SEM:0.99±0.30 cm). Moreover, we found a main effect of Group [F(1;98)=18.223; p<0.001; η^2_p =0.158], with a higher Proprioceptive Drift displayed by TD (mean±SEM:2.83±0.48 cm) as compared to ASC (mean±SEM:0.75±0.42 cm) individuals. Conversely, the main effect of RHI was no significant [F(1;98)=1.239; p=0.268], as well the interactions Stimulation*Group ([F(1;98)=0.985; p=0.323], Stimulation*RHI [F(1;98)=2.112; p=0.149], and RHI*Group [F(1;98)=0.584; p=0.461].
Crucially, a **significant Stimulation*RHI*Group interaction** was found [F(1;98)=4.986; p=0.028; η^2_p =0.048], showing that while in TD individuals the effectiveness of the illusion was comparable in visuo-tactile and tacto-tactile group, **in ASC individuals the illusion occurred only in tacto-tactile group**. Direct comparisons showed that in TD individuals the Proprioceptive Drift was significantly greater in synchronous than asynchronous stimulation in both tacto-tactile (p=0.042) and visual-tactile (p=0.007) group. Conversely, in **ASC** individuals the Proprioceptive Drift was significantly greater in synchronous than asynchronous only in the tacto-tactile group (p=0.002), but not in the visuo-tactile group (p=0.784). See Figure 2, top panel.

Embodiment Questionnaire

The 2*2*2 ANOVA performed on Embodiment Questionnaire scores revealed a main effect of Stimulation [F(1;98)=30.164; p<0.001; η^2_p =0.235], with greater scores in synchronous (mean±SEM:0.71±0.189) than asynchronous (mean±SEM: -0.42±0.20) stimulation, and a main effect of Group [F(1;98)=22.574; p<0.001; η^2_p =0.187], with a higher agreement showed by TD (mean±SEM:0.85±0.26) as compared to ASC (mean±SEM:-0.55±0.27) individuals. Conversely, the main effect of RHI was not significant [F(1;98)=0.733; p=0.394], as well the interactions Stimulation*Group [F(1;98)=2.398; p=0.125], Stimulation*RHI [F(1;98)=0.005; p=0.946], RHI*Group [F(1;98)=0.064; p=0.800], and Stimulation*RHI*Group [F(1;98)=0.163; p=0.687]. Direct comparisons showed that in TD individuals the Questionnaire scores were significantly greater in synchronous than asynchronous stimulation in both tacto-tactile (p<0.001) and visual-tactile (p=0.001) group. In **ASC** individuals, the reported scores are always below zero, thus never showing accordance to questionnaire items. However, scores are more negative after asynchronous than synchronous stimulation, exhibiting the same pattern of TD peers, despite direct comparisons are not significant. See Figure 2, bottom panel.

CONCLUSIONS

The present findings show that, while the visual-tactile procedure is not able to shift the perceived hand position toward the fake hand in ASC individuals, the **tacto-tactile procedure** is effective in **modulating proprioception** in ASC population, to a similar extent as that found in TD individuals. This evidence suggests that the integration of multiple inputs is more effective in ASC when administering two stimuli originating from the **same sensory channel**, thus revealing a **monochannel preference** in such population.

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References

1 Baum, SH et al., *Progress in Neurobiology* (201)
2 Cascio, CJ et al., *Autism* (2012)
3 Ropar, D et al., *Dev Cogn Neuroscience* (2015)
4 Lopez, C et al., *Neuroscience Letters* (2012)
5 Fossataro, C et al., *EJN* (2018)

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