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Impact of motor experience on perception/action coupling in children and teenagers with Autism Spectrum Disorder (ASD): an eye-tracking study



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Introduction

Atypies and motor difficulties in ASD

Disruption of the construction of action representations

Impact on perception/action coupling

Could the perception/action coupling be modulated by motor experience in ASD as it has been shown in typically developed children ?

① Validate a paradigm in eye-tracking using videos of daily actions to find a marker of perception/ action coupling

② Evaluate if age could influence the perception/action coupling by comparing fixation times and pupillar diameter

③ Evaluate if motor experience of the observed action could influence the asymmetry in fixation times in a visual preference paradigm

④ Evaluate if the variations of the pupil diameter could reflect the strenght of the perception/action coupling

Method

Participants: 55 => 7 to 17 years:

ASD group: 1 girls and 18 boys (Non verbal IQ ≥ 50).

Control group: 20 girls and 16 boys

Stimuli:

- 16 videos of daily actions (e.g. lace up his/her shoe) presenting with different degrees of motor familiarity to the participant.
- Displayed :
 - Forward = strong perception/action coupling
 - backward = weak perception/action coupling

Protocol:

Participants were comfortably seated in a chair (Fig.1) and were simply asked to watch 16 videos of daily actions, for 10 minutes.

a) familiarization phase → fixation times and pupil diameter within AOI (Figure 2)

b) visual preference test → fixation times within AOI (Figure 2)

Analysis and Statistics:

Data were recorded and extracted with EyeLink® Data Viewer, and processed with Matlab®. Statistics were performed with R®.

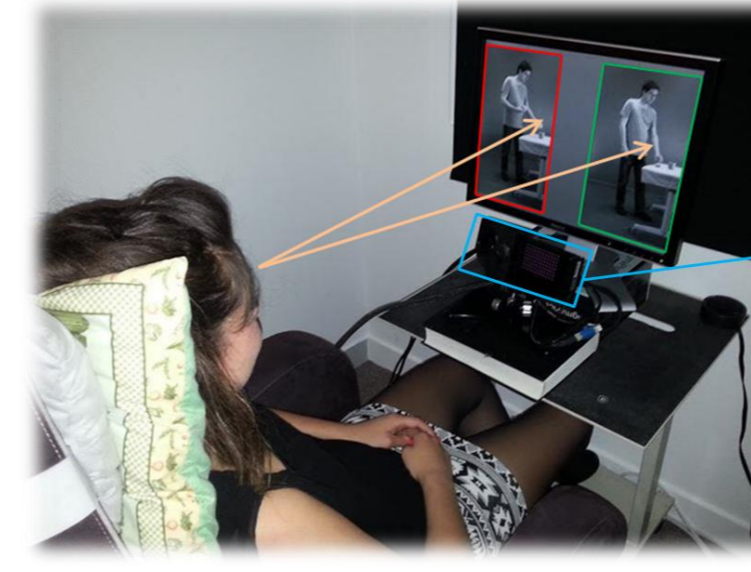
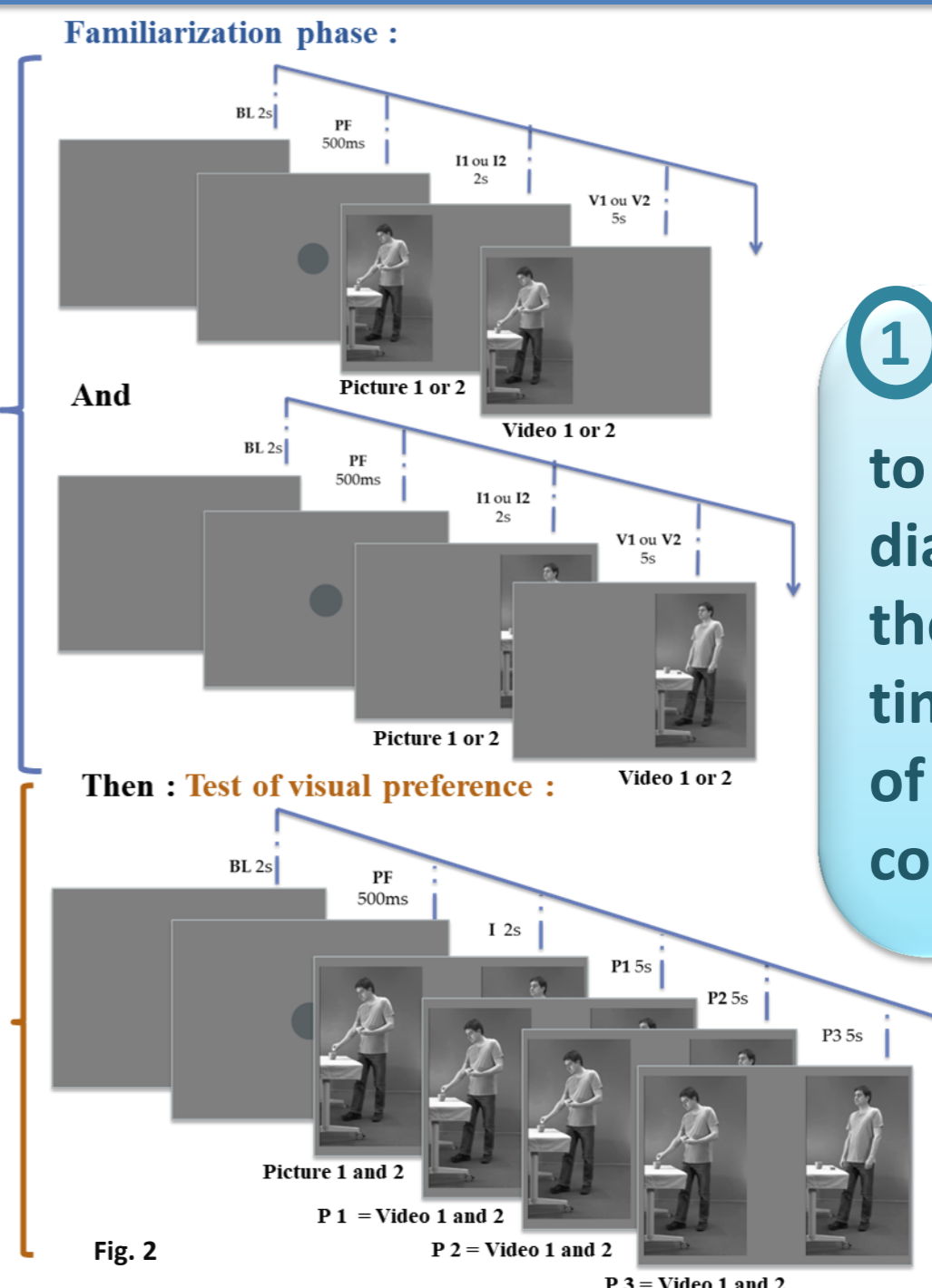


Fig. 1



① The paradigm enables us to extract from the pupil diameter measurement and the asymmetry in the fixation times, markers of the strenght of the perception/action coupling.

Results

Control group:

ASD group:

② Familiar vs Unfamiliar actions: typically developed children (7 to 17 years):

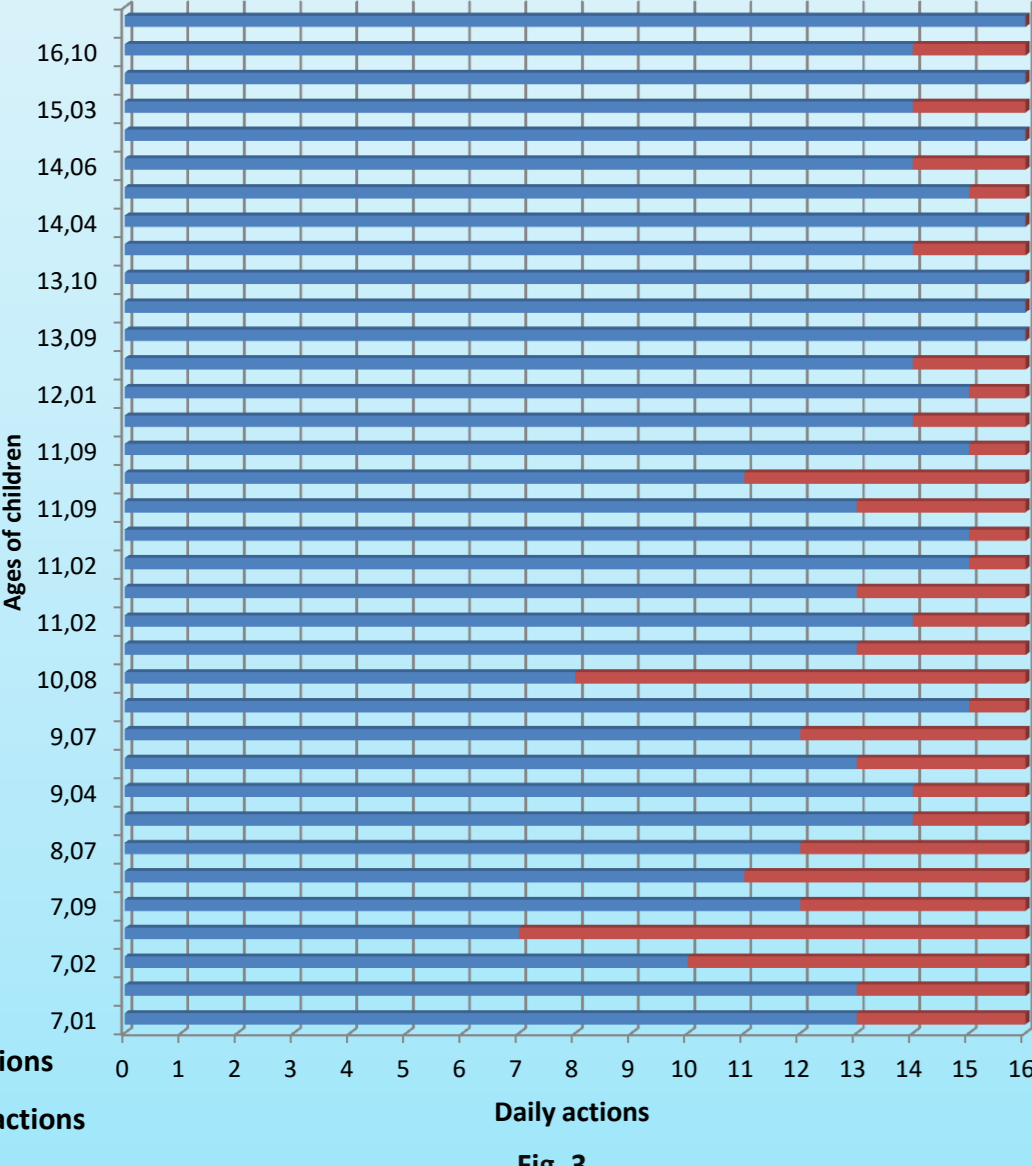


Fig. 3

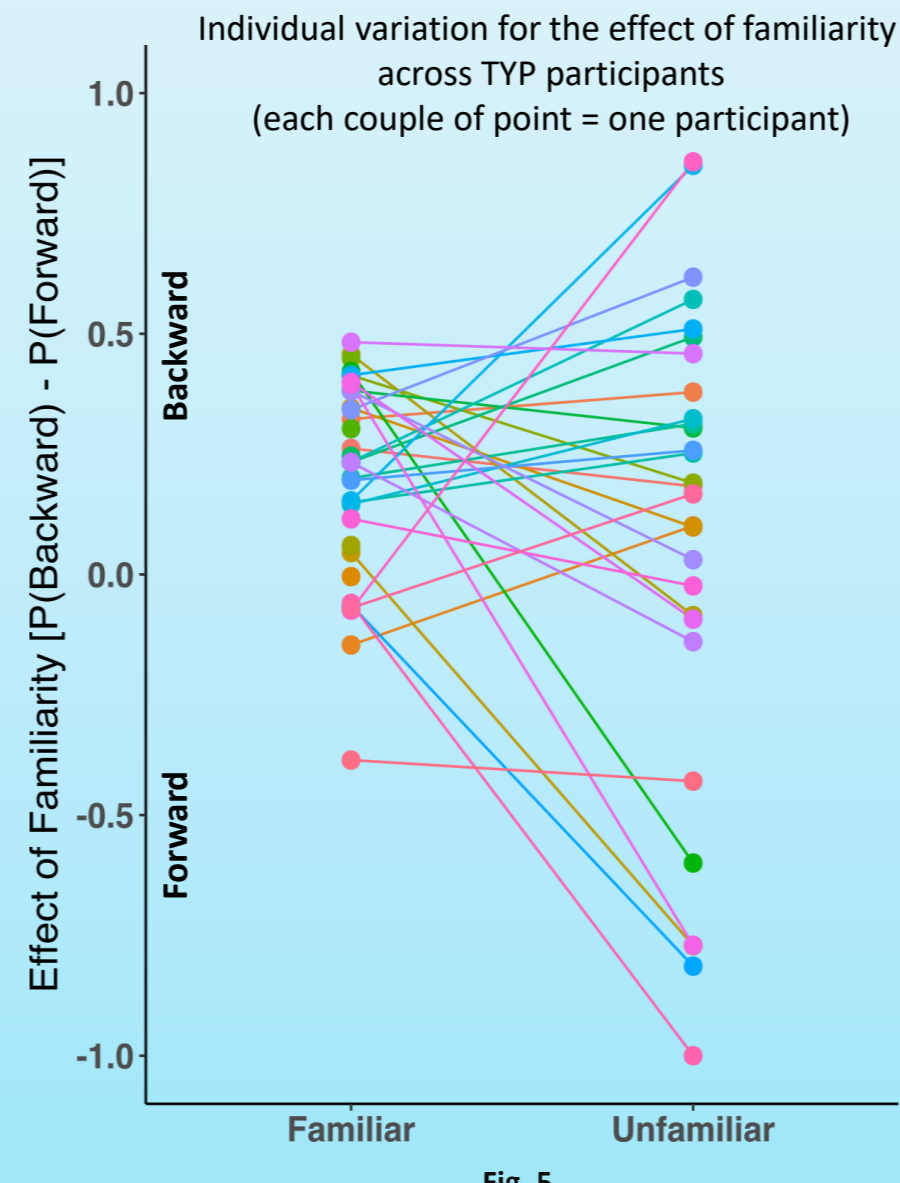


Fig. 5

The likelihood of looking at Backward vs. Forward actions at any given trial during the preference phase was modelled using Generalized Linear Mixed Models. Action familiarity, determined on an individual basis (Figure 3 and 4), was entered as a fixed effect. As random effects, we included a by-participants and by-items random intercept and a by-participants random slope.

Results indicated that the likelihood of looking at Backward vs. Forward videos was greater than chance for the TYP Group (OR = 1.84, $z = 3.74$, $p < .001$) but not for

the ASD group (OR = 1.31, $z = 1.86$, $p = 0.063$).

The by-participants random slope allowed us to model individual variation for the effect of familiarity (Figure 5 and 6). Removing this effect from the model significantly reduced the model fit in both groups, indicating that there is a reliable by-participant variation for the effect of familiarity.

Interestingly, accounting for this individual variation, the effect of familiarity remained significant in the TYP groups but not in the ASD group.

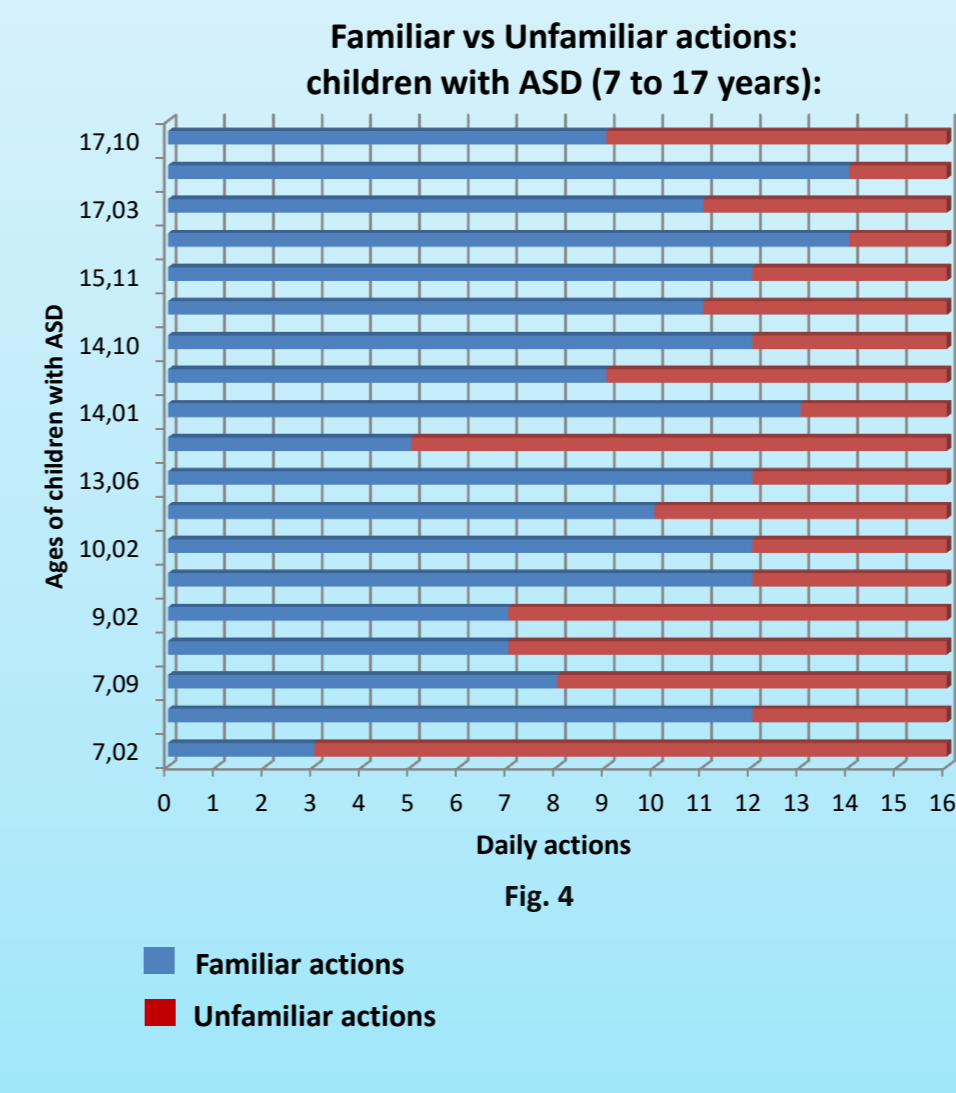


Fig. 4

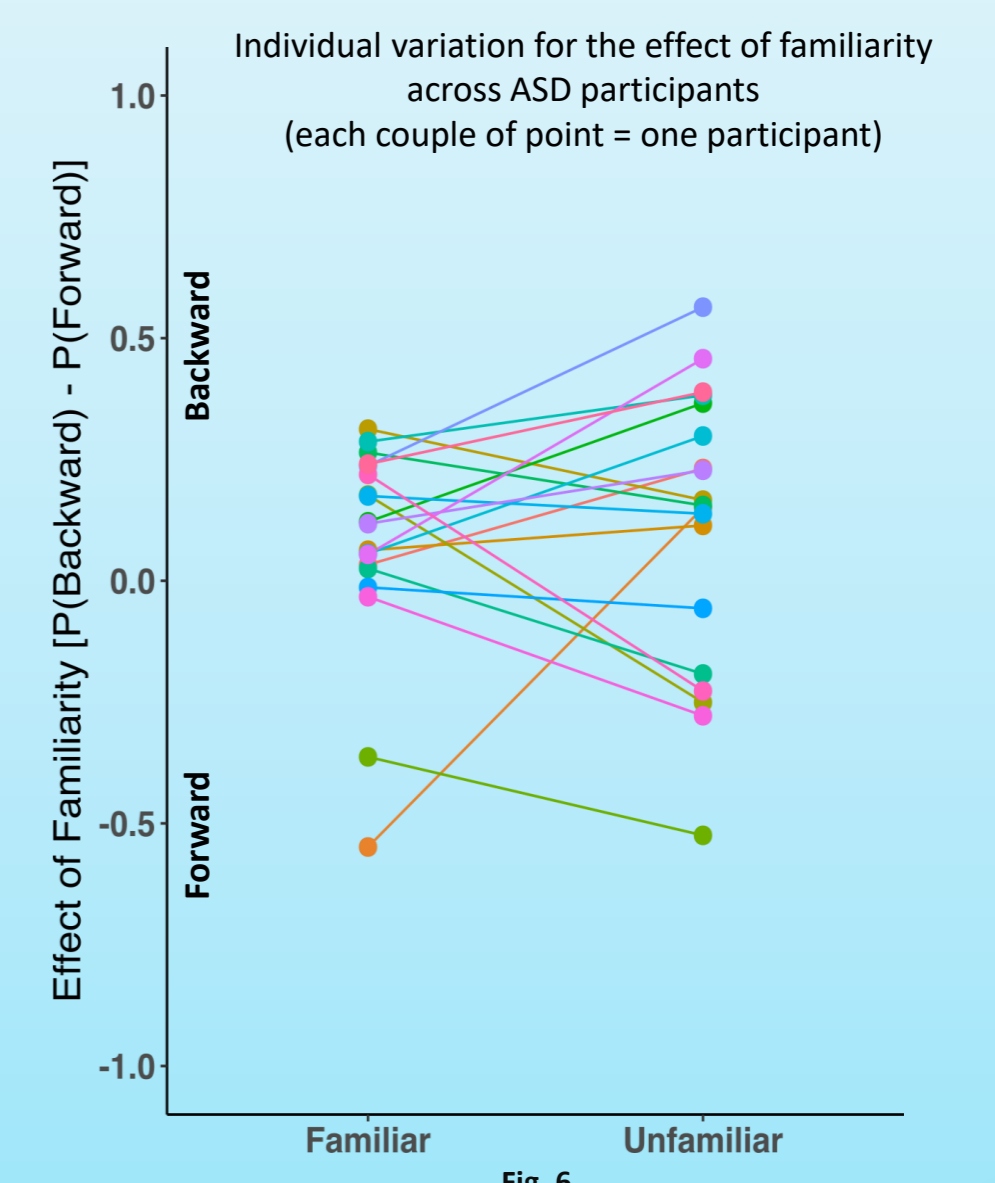
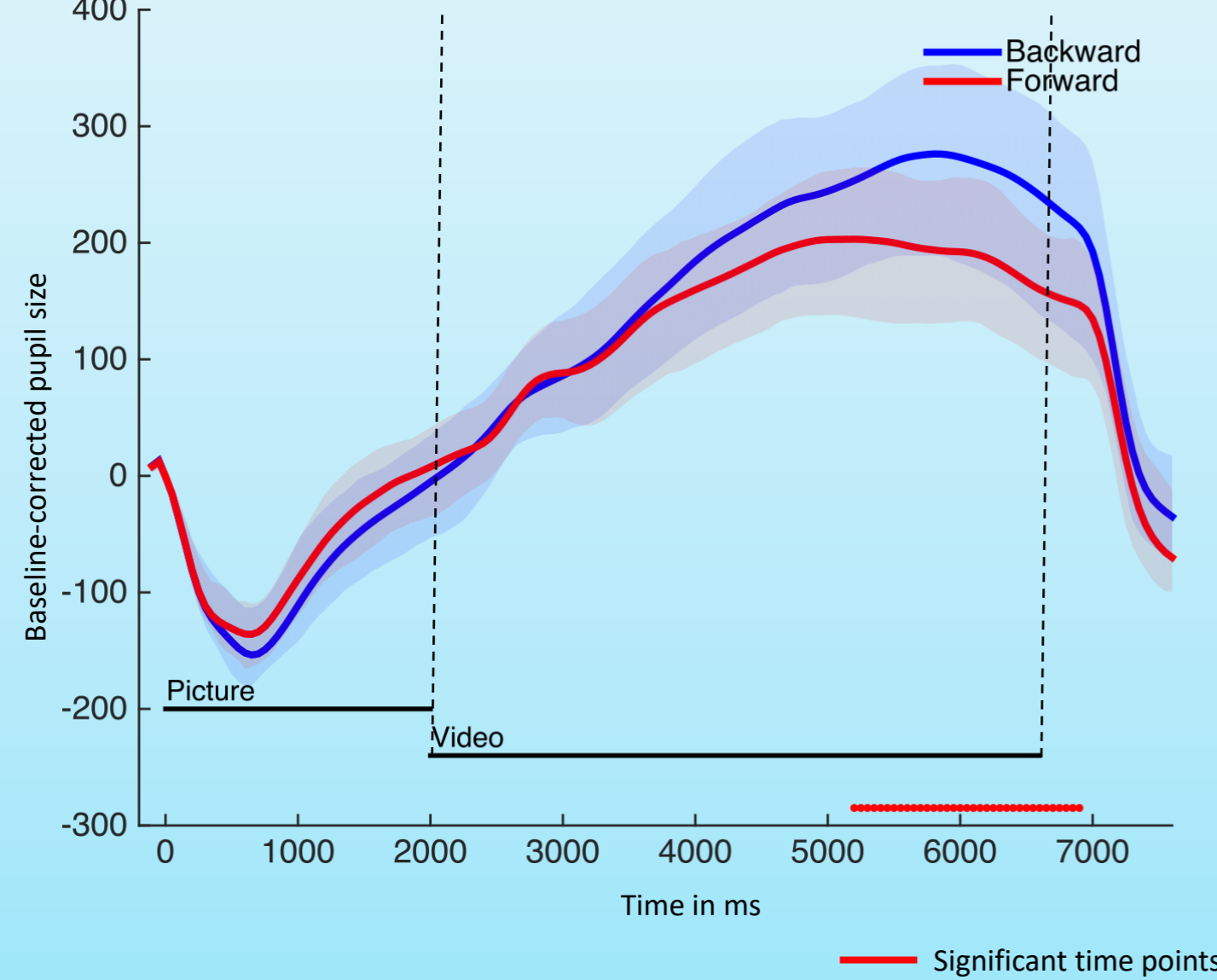


Fig. 6

③ Considering Age as a fixed effect in our model did not improve model fit significantly (compared to a null model without Age as a fixed effect), indicating that Age is not a significant predictor (i.e. Age does not account

for significant variation in the likelihood of looking at Backward vs. Forward actions). This was the case for both the TYP ($\chi^2 = 3.06$, $p = 0.080$) and ASD ($\chi^2 = 1.12$, $p = 0.291$) in both groups.

④ Pupil Diameter Time Course during Backward and Forward video displays (robust mean and 95% Confidence Interval)

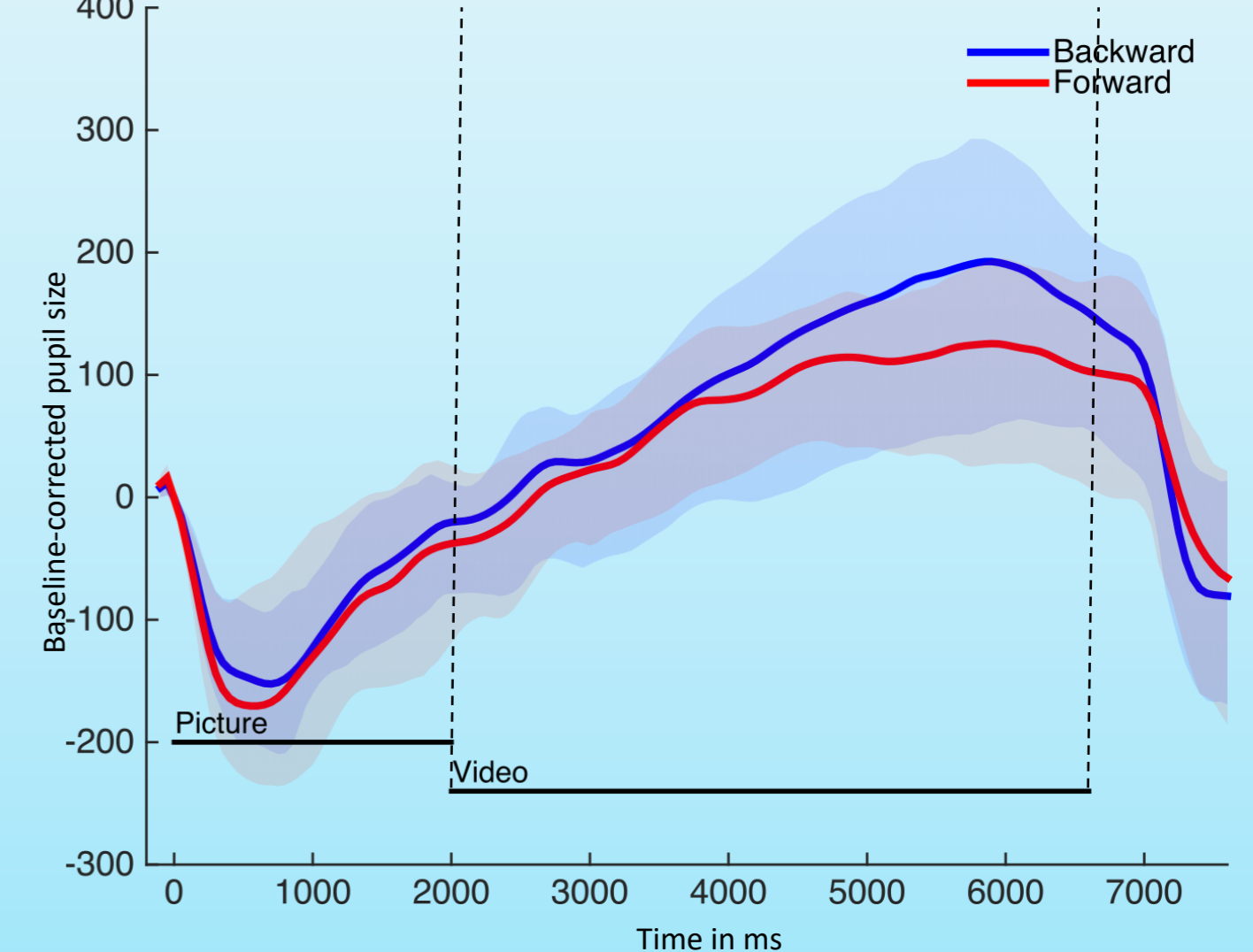


Average time course of the pupil diameter across participants for backward (blue line) and forward (red line) displays during the Familiarization phase.

Shaded areas denote the 95% confidence intervals around the trimmed mean established at each time point (20Hz).

The timing of events within each trial (picture, video) is depicted with solid horizontal lines. The red dots along the x-axis mark the time points at which the two pupil size differ significantly as indicated by a bootstrap t-test and based on a cluster threshold method to control for multiple comparisons.

④ Pupil Diameter Time Course during backward and forward video displays (robust mean and 95% Confidence Interval by condition)



Conclusion

① We designed and validated an eye-tracking paradigm that enable to quantify the existence of a perception/action coupling using an asymmetry fixation duration index and the variation of the pupil diameter. This paradigm is easy to use in very young children with ASD, including those with intellectual disability.

② The strength of the perception/action coupling was modulated by the motor experience specific to each participant in typically developed children, with a strong individual variability. This effect was not found in children with ASD.

③ Age did not influence the measure of the perception/action coupling (even if a tendency was found in typically developed children)

④ The time course if the pupil diameter variation reflected the strenght of the perception/action coupling in typically developed children. Such a difference was not found in children with ASD.

Taken together, these results are rather in favor of a lack of perception/action coupling in children with ASD. However, our study reveals the influence of the individual motor experience. Further studies should control for this factor to be conclusive.