Autistic Children’s Visual Sensitivity to Face Movement

Details for analyzing gaze difference map

The proportional looking-time heatmaps were generated as follows. First, for each valid trial of each participant, the total fixation duration in each pixel of the whole stimuli was calculated. Second, the proportional looking time in each pixel was calculated by dividing the total looking time in each pixel by the total looking time on the whole stimuli. Third, the above heatmaps were smoothed using a 2° full width at half maximum (FWHM) Gaussian kernel spatial filter (Kennedy et al., 2017). Finally, for each child, the smoothed heatmaps were averaged together for each condition.

For each condition, we used z-tests to compare the two groups’ proportional looking-time heatmaps at the pixel level with the cluster-based permutation test to control the family‐wise error rate since adjacent regions are likely to exhibit the same effect (Maris & Oostenveld, 2007). To reduce memory usage and computational time, we down-sampled the heatmaps to 20% of the original size and applied a mask to only model the pixels within the face region. As we can see from Figure 4, both ASD and non-ASD groups mainly looked at the face region, sparse outlines outside the face are very likely to generate erroneous estimation.

We first generated the empirical difference heatmap by subtracting the non-ASD group’s heatmap from the ASD group’s heatmap. It was then converted to a statistical difference Zmap relative to the permuted difference heatmap. To obtain the permuted difference heatmap, we randomly shufﬂed participant labels (ASD or non-ASD) 1000 times and calculated the difference heatmap as described above. The significance threshold was set to the 97.5th quantile of a Z-distribution, meaning that data points in the difference Zmap with |*z*| ≤ 1.96 were set to zero. Nonzero data points with shared edges were deﬁned as belonging to the same cluster. Summed values of *z* in each cluster were calculated (i.e., cluster-mass Z statistic). These empirical cluster values were compared to a null distribution based on a permutation test. To obtain the null distribution, each permuted difference map was converted to a statistical Zmap relative to the 1000 permuted difference maps, and we extracted clusters with the largest summed absolute values of *z*, resulting in 1000 permutation cluster values (if no cluster was found in one permuted procedure, a cluster value of 0 was assumed). Then, we ranked each empirical cluster within the distribution of all permutation clusters. For a two-tailed test, empirical clusters with summed values of *z* greater than the 97.5th quantile or less than the 2.5th quantile of the null distribution were statistically significant.

Detailed results of supplementary analyses

We reanalyzed the overall proportional eye‐looking and mouth-looking time with the age- and gender-matched sample. This matched sample included 125 autistic children and adolescents (106 boys) and 125 non-autistic children and adolescents (102 boys). Figure S1(B) shows the age distribution for the two matched groups (*M*ASD = 7.14 years, *SD*ASD = 2.98 vs. *M*non-ASD = 7.61 years, *SD*non-ASD = 2.86), *t* (247.57) = -1.27, *p* = .206.

*Overall proportional eye‐looking time*

The results are shown in Figure S5(A) and Table S3. The ANOVA showed that both the main effects of Group and Condition were significant, *F*(1, 248) = 8.48, *p* = .004, ηG2 = .023, and *F*(1.99, 494.63) = 239.51, *p* < .001, ηG2 = .240, respectively. The interaction between Group and Condition was also significant, *F*(1.99, 494.63) = 7.86, *p* < .001, ηG2 = .010. Post hoc tests revealed that autistic participants looked less at the eyes than non-autistic participants in the blink (*M*ASD = .45, *SD*ASD = .25 vs. *M*non-ASD = .57, *SD*non-ASD = .27) and static (*M*ASD = .38, *SD*ASD = .24 vs. *M*non-ASD = .45, *SD*non-ASD = .22) conditions, *t* (248) = -3.65, *p* < .001 and *t* (248) = -2.44, *p* = .015, respectively, but not in the moving-mouth (*M*ASD = .21, *SD*ASD = .16 vs. *M*non-ASD = .22, *SD*non-ASD = .17) condition, *t* (248) = -0.49, *p* = .626. Post hoc tests also revealed a ranking order among three conditions for both the autistic and non-autistic groups: participants looked at the eyes longest in the blink condition, and they looked at the eyes longer in the static than the moving-mouth conditions, all *p*s < .05.

*Overall proportional mouth‐looking time*

The results are shown in Figure S5(B) and Table S4. The ANOVA showed that both the main effects of Group and Condition were significant, *F*(1, 248) = 8.14, *p* = .005, ηG2 = .017, and *F*(1.46, 362.02) = 331.55, *p* < .001, ηG2 = .381, respectively. The interaction between Group and Condition was also significant, *F*(1.46, 362.02) = 7.29, *p* = .003, ηG2 = .013. Post hoc tests revealed that autistic participants looked less at the mouth than non-autistic participants in the moving-mouth (*M*ASD = .35, *SD*ASD = .26 vs. *M*non-ASD = .46, *SD*non-ASD = .24) condition, *t* (248) = -3.30, *p* = .001, but not in the blink (*M*ASD = .09, *SD*ASD = .12 vs. *M*non-ASD = .09, *SD*non-ASD = .13) and static (*M*ASD = .12, *SD*ASD = .12 vs. *M*non-ASD = .15, *SD*non-ASD = .14) conditions, *t* (248) = -0.45, *p* = .653 and *t* (248) = -1.86, *p* = .064, respectively. Post hoc tests also revealed a ranking order among three conditions for both the autistic and non-autistic groups: participants looked at the mouth longest in the moving-mouth condition, and they looked at the mouth longer in the static than the blink conditions, all *p*s < .05.

Supplementary tables

Table S1. Mean (stand deviation) of overall proportional eye‐looking time for different groups and conditions.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Blinking | Static | Moving-mouth |
| ASD | .45 (.25) | .37 (.24) | .21 (.16) |
| non-ASD | .57 (.27) | .46 (.23) | .22 (.17) |

Table S2. Mean (stand deviation) of overall proportional mouth‐looking time for different groups and conditions.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Blinking | Static | Moving-mouth |
| ASD | .09 (.13) | .13 (.14) | .35 (.26) |
| non-ASD | .09 (.13) | .14 (.14) | .45 (.24) |

Table S3. ANOVA results of the overall proportional eye-looking time for the matched sample.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Effect | *df* | *F* | *p* | η G 2 |
| Group | 1, 248 | 8.48 | .004 | .023 |
| Condition | 1.99, 494.63 | 239.51 | <.001 | .240 |
| Group × Condition | 1.99, 494.63 | 7.86 | <.001 | .010 |

Table S4. ANOVA results of the overall proportional mouth-looking time for the matched sample.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Effect | *df* | *F* | *p* | η G 2 |
| Group | 1, 248 | 8.14 | .005 | .017 |
| Condition | 1.46, 362.02 | 331.55 | <.001 | .381 |
| Group × Condition | 1.46, 362.02 | 7.29 | .003 | .013 |

Supplementary figures



**Figure S1.** The age distribution for the ASD and non-ASD groups.



**Figure S2.** The histogram of the interpolation proportion for the ASD and non-ASD groups.



**Figure S3.** Statistical results of the temporal course of eye‐looking time when Age was added to the interaction with Group and Condition. The dotted horizontal line represents the threshold set to the 95% percentile of the *F* statistic. The red part shows significant time periods. This plot shows the *F* statistic on the vertical Y-axis against the time epoch on the horizontal x-axis. From top to down: effects of Group, Condition, Age, interaction between Group and Condition, interaction between Group and Age, interaction between Condition and Age, and interaction between Group, Condition, and Age across time.



**Figure S4.** Statistical results of the temporal course of mouth‐looking time when Age was added to the interaction with Group and Condition. The dotted horizontal line represents the threshold set to the 95% percentile of the *F* statistic. The red part shows significant time periods. This plot shows the *F* statistic on the vertical Y-axis against the time epoch on the horizontal x-axis. From top to down: effects of Group, Condition, Age, interaction between Group and Condition, interaction between Group and Age, interaction between Condition and Age, and interaction between Group, Condition, and Age across time.



**Figure S5.** Overall proportional eye-looking time and mouth-looking time with the age- and gender-matched sample.