Autism spectrum disorder (ASD) is a complex developmental disorder that includes impairments in social interaction, communication skills and presence of repetitive behaviors (APA, 2013). The CDC estimates that rates of autism are almost five times higher in boys than among girls (CDC, 2014).

Implicit learning tasks have demonstrated that ASD children have atypical neural responses to social rewards, and it seemed to negatively impact their implicit learning relative to typically developing (TD) children (Van Zeeland, Dapretto, Ghaemreani, et al., 2010). TD boys are also more likely to learn faster and benefit more from implicit learning than girls (Fan, 2002), which has not been examined in ASD.

This study explored whether the presence of social and non-social feedback can impact implicit learning in children with ASD, and whether implicit learning differs between genders.

We hypothesized that 1) TD children will have better accuracy to stimuli associated with social feedback compared to ASD children, and 2) within the ASD group, the ASD boys will show enhanced implicit learning to social feedback compared to the ASD girls.

Results

Question 1: Are there group or gender difference in implicit learning?

In Figure 1 and 2, an ANOVA was calculated for error, with Group (ASD, TD) and Gender (Male, Female) as independent variable for Rewarded and Non-rewarded tasks respectively.

- Error to Social Feedback in the Rewarded Task: No main effects of gender or group, no interactions.
- Error to Nonsocial Feedback in the Rewarded Task: No main effects of gender or group, no interactions.

In Figure 3, a Repeated Measures ANOVA was used for Rewarded Social Feedback Error across Blocks (1, 2, 3) between groups (ASD, TD).

- There was a main effect of block, F(2, 71) = 4.270, p = .018. There was no significant block x group interaction. Follow up tests run separately on ASD and TD groups found that there was no main effect of block within the ASD group (p = .195) while the TD group showed a marginal effect of block, $F(2, 27) = 2.87, p = .07$, with significantly higher error in Block 1 compared to Block 3 (p = .021).

In Figure 4, a Repeated Measures ANOVA was conducted for Rewarded Social Feedback Error across Blocks (1, 2, 3) between groups (ASD, TD).

- There was a main effect of block $F(2, 71) = 7.21, p = .001$. There was no significant block x group interaction. Follow up tests run separately on ASD and TD groups found that there was a main effect of block in the ASD group, $F(2, 43) = 9.42, p = .000$ with error decreasing significantly across all blocks. There was no main effect of block for the TD group (p = .223).

Discussion

Summary

We found that there were no gender differences in ASD and TD groups in their implicit learning to social or non-social feedback. There were also no overall group differences during the non-rewarded block, but the TD group made fewer errors than the ASD group to stimuli with non-social feedback during the Non-rewarded task.

Unlike overall results, there was a marginal difference in learning across blocks, the TD group had significantly lower error in Block 3 than Block 1 in the Rewarded task with Social Feedback, while the ASD group made significantly fewer errors across blocks in the Rewarded task with Nonsocial Feedback. This indicated that both ASD and TD groups learned implicitly, but that the kind of feedback they receive might matter differently to each group. Although TD group only showed marginal difference across blocks in implicit learning with Nonsocial Feedback in the Rewarded task, TD group made significantly less errors than ASD group.

Conclusion

- Overall, both hypotheses were not supported, as there were no overall differences were found in implicit learning between group or gender. This suggests that we may need a larger sample size to expand these findings.
- The findings suggest minor group differences in learning patterns, as the ASD group learned better with Social Feedback than Nonsocial Feedback, but opposite for the TD group. External reward did not seem to not affect implicit learning in the ASD group as it did to the TD group.

Methods

Participants:

<table>
<thead>
<tr>
<th></th>
<th>ASD Female</th>
<th>ASD Male</th>
<th>TD Female</th>
<th>TD Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Participants</td>
<td>18</td>
<td>27</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Mean Age (months)</td>
<td>144.59 (SD = 13.45)</td>
<td>141.59 (SD = 13.45)</td>
<td>122.80 (SD = 14.51)</td>
<td>137.79 (SD = 16.52)</td>
</tr>
<tr>
<td>Mean Verbal IQ</td>
<td>100.17 (SD = 17.64)</td>
<td>96.79 (SD = 17.64)</td>
<td>102.95 (SD = 15.71)</td>
<td>111.71 (SD = 17.64)</td>
</tr>
</tbody>
</table>

Procedures:

All participants completed an implicit learning task twice under different conditions: Non-Reward in which participants completed the task without any outside incentive, and Rewarded, in which the participants were told if they “did well enough”, they would receive a prize of their choice (gift card, candy or toy). Each task, both Non-Reward and Rewarded, had 3 blocks with 40 trials each.

During the task, children were asked to decide (by pressing a button “1” or “2”) if a picture belonged in “Group 1” or “Group 2”. Following their choice, they were given either positive or negative social or nonsocial feedback. The experimenters told the participants that there was a bug or glitch in the computer, such that the feedback was not always correct. Feedback was 80% consistent or “correct”.

Social Feedback

- Group 1 (80% correct)
- Group 2 (20% correct)

“Right”

Nonsocial Feedback

- Group 1 (20% correct)
- Group 2 (80% correct)

“Wrong”

Conclusion

We found that there were no gender differences in ASD and TD groups in their implicit learning to social or non-social feedback. There were also no overall group differences during the non-rewarded block, but the TD group made fewer errors than the ASD group to stimuli with non-social feedback during the Non-rewarded task.

Unlike overall results, there was a marginal difference in learning across blocks, the TD group had significantly lower error in Block 3 than Block 1 in the Rewarded task with Social Feedback, while the ASD group made significantly fewer errors across blocks in the Rewarded task with Nonsocial Feedback. This indicated that both ASD and TD group learned implicitly, but that the kind of feedback they receive might matter differently to each group. Although TD group only showed marginal difference across blocks in implicit learning with Nonsocial Feedback in the Rewarded task, TD group made significantly less errors than ASD group.

Conclusion

- Overall, both hypotheses were not supported, as there were no overall differences were found in implicit learning between group or gender. This suggests that we may need a larger sample size to expand these findings.
- The findings suggest minor group differences in learning patterns, as the ASD group learned better with Social Feedback than Nonsocial Feedback, but opposite for the TD group. External reward did not seem to not affect implicit learning in the ASD group as it did to the TD group.