Evaluating ePeekaboo: A Novel Eye Tracking Paradigm for Studying Anticipatory Behavior in Preschool-Aged Children

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BACKGROUND

- Alterations in reward processing are a key mechanism of the social motivation hypothesis of autism.[1]
- Widely used reward processing tasks (Doors Guessing, Incentive Delay) require complex cognition and motor responses (e.g., button presses), limiting their feasibility in younger populations and constraining our understanding of the early development of reward processing.
- Age-appropriate, passive eye tracking tasks may index components of reward processing in early childhood.[2,3]
- ePeekaboo is a passive eye tracking task designed to assess contingency learning and anticipation via anticipatory saccades, providing a potential method for indexing reward processing components in early childhood.

AIMS

- This study seeks to (1) determine whether ePeekaboo measures contingency learning, (2) assess differences by age and diagnosis (TD vs ASD), (3) evaluate the effect of condition (nonsocial vs social) on learning

METHODS

Participants

- 44 typically developing (TD) and 11 autistic (ASD) 3-5-year-olds (Table 1).

Eye Tracking

- Data recorded using a Tobii Pro Fusion eye tracker sampled at 120Hz[4].
- Fixations extracted using dispersion-threshold algorithm for fixation identification (I-DT).
- Angular threshold of 0.5°.

Anticipatory Looking

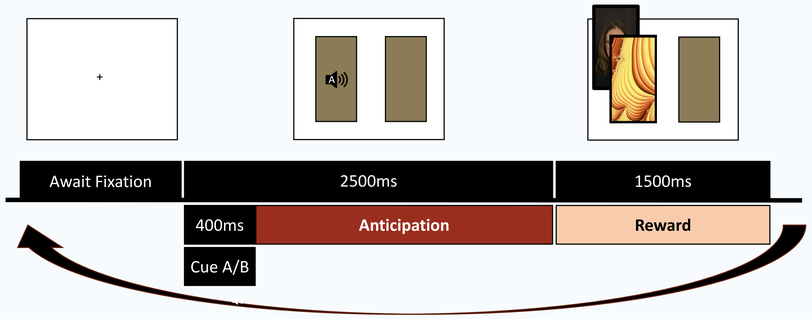
- Target fixation proportion: proportion of time spent looking at the correct door out of the total time spent looking at either door.
- Fixation proportion: proportion of time spent looking at either door during the 2500ms anticipation period.

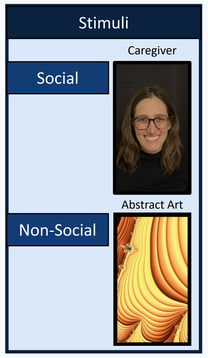
Analysis

Linear mixed effects model implemented (lme4) in R

- Target fixation proportion ~ $\beta_0 + \beta_1$*Trial + 1 | Subject + ε_{ij}
- Target fixation proportion ~ $\beta_0 + \beta_1$*Trial + β_2*DXGroup + β_3(Trial*DXGroup) + 1 | Subject + ε_{ij}
- Target fixation proportion ~ $\beta_0 + \beta_1$*Trial + β_2*Age + β_3(Trial* Age) + 1 | Subject + ε_{ij}
- Target fixation proportion ~ $\beta_0 + \beta_1$*Trial + β_2*CondOrder + β_3(Trial*CondOrder) + 1 | Subject + ε_{ij}
- Fixation proportion ~ $\beta_0 + \beta_1$*Trial + 1 | Subject + ε_{ij}

TASK





ePeekaboo: 10 baseline trials → 30 social trials → 30 nonsocial trials

RESULTS

Table 1: Demographics

	All	TD	ASD
Total N	55	44	11
Age, years (Mean ± SD)	4.26 (0.97)	4.17 (0.93)	4.61 (1.08)
Gender (M:F, %F)	30:25 (45.5%)	24:20 (45.5%)	6:5 (45.5%)
Ethnicity: Hispanic	17 (15.5%)	11 (10%)	6 (5.5%)
Ethnicity: Not Hispanic	37 (33.6%)	32 (29.1%)	5 (4.5%)
Ethnicity: Multi Hispanic	1 (0.9%)	1 (0.9%)	0 (0%)
Race: African American	3 (5.5%)	3 (6.8%)	0 (0%)
Race: White	41 (74.5%)	34 (77.3%)	7 (63.6%)
Race: Other	1 (1.8%)	0 (0%)	1 (9.1%)
Race: Multiple Races	10 (18.2%)	7 (15.9%)	3 (27.3%)

Figure 1: Anticipatory Fixations to Target Across Trials

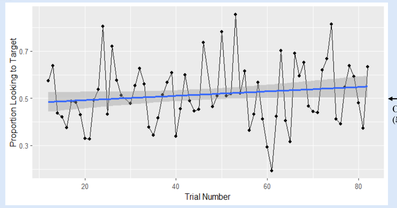


Figure 1. TD group only. Over trials, participants did not show increased anticipatory saccades to the side where the reward would appear (ß = 0.0009, SE = 0.0006, t = 1.61).

Figure 2: Anticipatory Fixations to Target Across Trials by Diagnostic Group

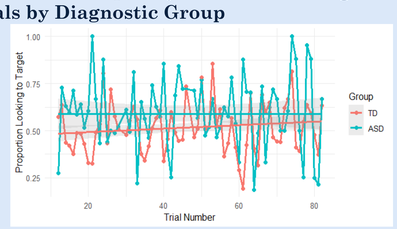


Figure 2. Over trials, there were no significant changes in anticipatory saccades to the side where the reward would appear based on trial, diagnostic group, or their interaction (trial: ß = 0.0009, t = 1.60; group: ß = 0.11, t = 1.77; interaction: ß = -0.0010, t = -0.82).

Figure 3: Anticipatory Fixations to Target Across Trials by Age Group

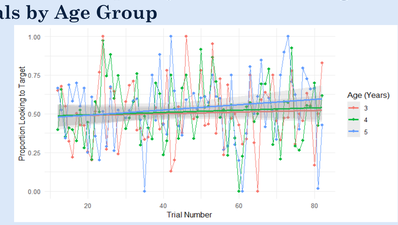


Figure 3. TD group only. Over trials, there were no significant changes in anticipatory saccades to the side where the reward would appear based on trial, age, or their interaction (trial: ß = -0.0010, t = -0.38; age: ß = -0.0088, t = -0.25; trial × age: ß = 0.0005, t = 0.72).

Figure 4: Anticipatory Fixations to Target by Condition (Social vs Non-Social First)

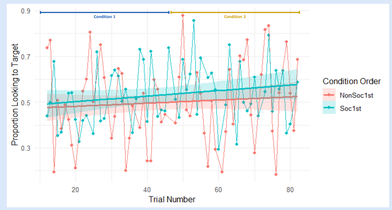


Figure 4. TD group only. Over trials, there were no significant changes in anticipatory saccades to the side where the reward would appear based on whether social or nonsocial stimuli appeared first (trial: ß = 0.0007, t = 0.87; condition order: ß = 0.01, t = 0.18; interaction: ß = 0.0005, t = 0.43).

Figure 5: Attention to Either Door Across Trials

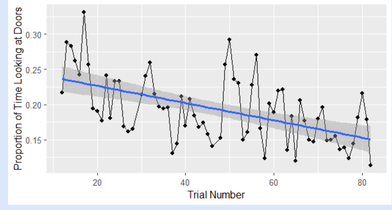


Figure 5. TD group only. Over trials, participant attention to the task stimuli declined significantly (ß = -0.0012, t = -5.91, p <0.001).

DISCUSSION

- Children demonstrated no change in anticipatory saccades across trials, indicating limited evidence of learning the cue-side contingency. There were no differences by age, diagnosis, or condition order.
- Children showed low and decreasing attention to the stimuli during the anticipation window (looking at the doors <25% of the anticipation time window), suggesting that fatigue or limited engagement may contribute to the absence of detectable learning effects.
- The current paradigm may not sufficiently capture contingency learning in young children, highlighting the need to improve engagement or task design.

FUTURE DIRECTIONS

- Enhance engagement with more salient or other age-tailored rewards and consider shorter anticipation periods to maintain attention and optimize the learning measurement.
- Explore additional eye tracking metrics (e.g., time-binned anticipatory fixations, first- and last-look latencies, spatial biases, and engagement indicators) to better capture learning, attention, and anticipation in young children.
- Compare performance with established reward paradigms (i.e., Doors Guessing task) to contextualize findings.
- Increase sample size of autistic cohort and assess individual differences in learning and anticipation.

ACKNOWLEDGEMENTS

This project is supported by a NARSAD Young Investigator Grant (32408) from the Brain & Behavior Research Foundation, and generous donors. We would like to thank the families who participated in the TREAT Study, lab members who collected data, & BRAIN Lab Community Advisory Board Members.

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