# The Reward Positivity in Early Childhood: Age, Feedback, and Trial-Level Dynamics in an Adapted Doors Task

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## Introduction

- Response to reward is a key aspect of the social motivation of hypothesis of autism and social development more broadly; however, its trajectory in early childhood is not well understood.[1]
- The Reward Positivity (RewP) can be observed with electroencephalography (EEG) and reflects differentiation between the neural responses to reward vs loss, seen as positivity in the reward condition between 250 – 550 ms. [2]
- The RewP is reliably elicited by the Doors task[3], a simple guessing task validated in adults and children as young as 4 years.[4,5] The RewP has not yet been reliably observed in 3-year-olds.
- Given the high variability in children's event-related potentials (ERPs), trial-by-trial analyses that model reward processing dynamically may be useful for preserving variability and accounting for developmental issues like fatigue and inattention.[6]
- Characterizing intraindividual patterns of reward processing provides more nuanced understanding and more precise measurement of response to reward in young children, facilitating more rigorous investigation of how early reward sensitivity shapes social learning, social motivation, and cognitive development in neurotypical and autistic populations.

## Objectives

1. Examine intraindividual variability in the Reward Positivity elicited by an adapted Doors Task across trials and conditions (i.e., desired/undesired prizes)
2. Determine whether changes across trials and condition differ across age

## Methods

**Participants:** 73 preschoolers, ages 3-5, typically developing
**Paradigm**: Adapted Doors Task (Figure 1)
**ERP Component (RewP):**

1. For each participant, averaged all trials, then computed a difference wave (gain – loss) and identified peak amplitude between 250–550ms post feedback (desired or undesired)
2. For each trial, extracted mean amplitude during 100ms window centered on peak identified in Step 1
3. Analyzed using quadratic linear mixed-effect models:

**Table 1.** Demographics

| | n | % |
|---|---|---|
| N | 73 | 49.3 (F) |
| Age (months) | | |
| Mean (SD) | 52.23 (11.01) | |
| Range | 36 - 71 | |
| Race | | |
| White | 59 | 80.8 |
| Black | 6 | 8.2 |
| Multi-race | 8 | 11 |
| Hispanic | | |
| Yes | 13 | 17.8 |
| No | 60 | 82.2 |

$$\text{Amplitude} = \beta_0+\beta_1(\text{Condition})+\beta_2(\text{Age centered})+\beta_3(\text{Trial})+\beta_4(\text{Trial}^2)+\beta_5(\text{Age centered} \times \text{Trial})+\beta_6(\text{Age centered} \times \text{Trial}^2)+u_{0j}+\epsilon_{ij}$$

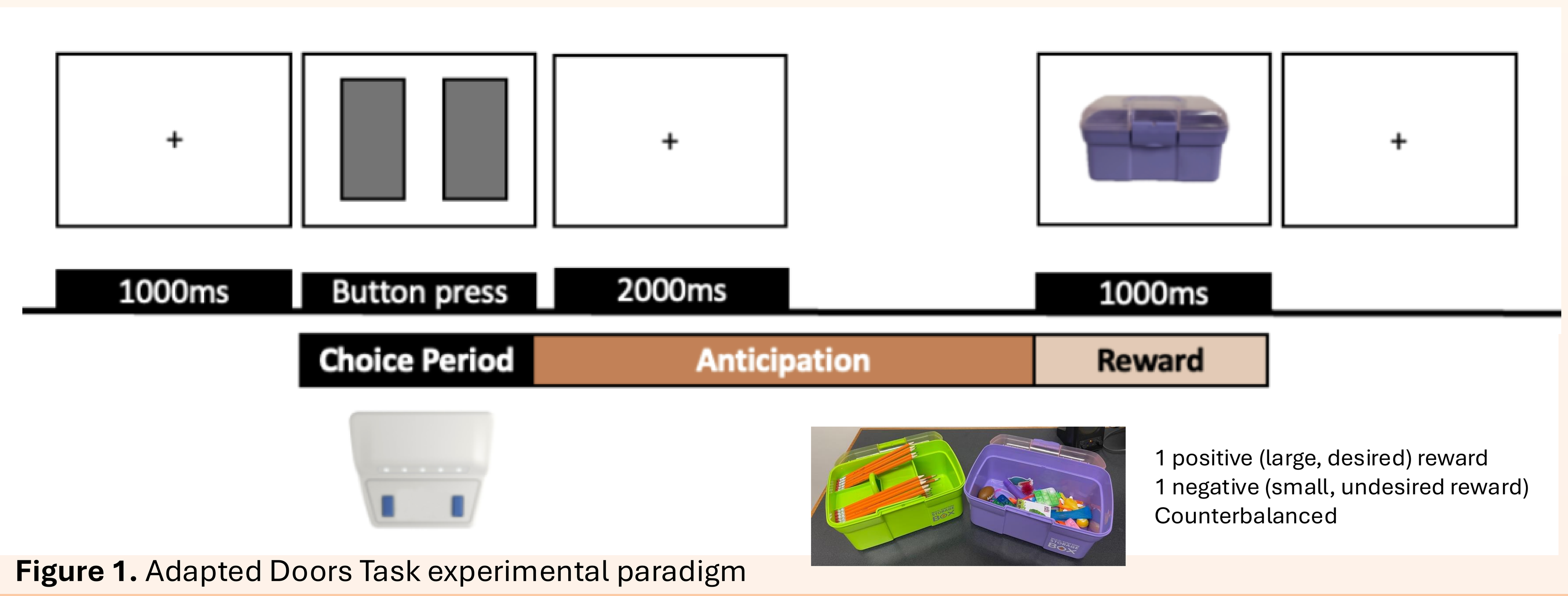


**Figure 1.** Adapted Doors Task experimental paradigm

## Discussion

- Over the course of the task, neural response to reward amplitude **increased, peaked mid-task, then decreased.** Children may respond more strongly to the prize as they learn task contingencies, then response may diminish due to habituation, reduced novelty, or decreased engagement over time. Shortening the task or excluding later trials may improve measurement of reward sensitivity and reduce attenuation of observed effects.
- **Age influenced how responses changed over trials in both linear and quadratic terms** (p = .003, .085), suggesting that older children showed greater increases in mean amplitude across trials compared to younger children. Specifically, age affected how much responses increased over trials in amplitude, suggesting developmental differences in learning, motivation, engagement, and habituation.
- Findings suggest developmental **differences in how neural responses change over repeated trials, independent of experimental condition.**

## References

[1]Chevallier et al. Trends Cogn Sci. 16(4), 231–239. (2012)
[2]Proudfit. *Psychophysiology. 52*(4), 449–459 . (2015)
[3]Carlson et al. *NeuroImage. 57*(4), 1608–1616. (2011)
[4]Hennefield et al. *Dev Science*. *25*(3), e13196. (2022)
[5]Belden. *JAACAP. 55*(12), 1081–1089. (2016)
[6]Heise et al. *Dev Cog Neuro.* (2022)

## Results

**Objective 1:** Mean amplitude increased across trials and then decreased later in the task (significant linear effect of trial, *β* = 0.38, *p* < .001, significant quadratic effect, *β* = −0.006, *p* < .001).

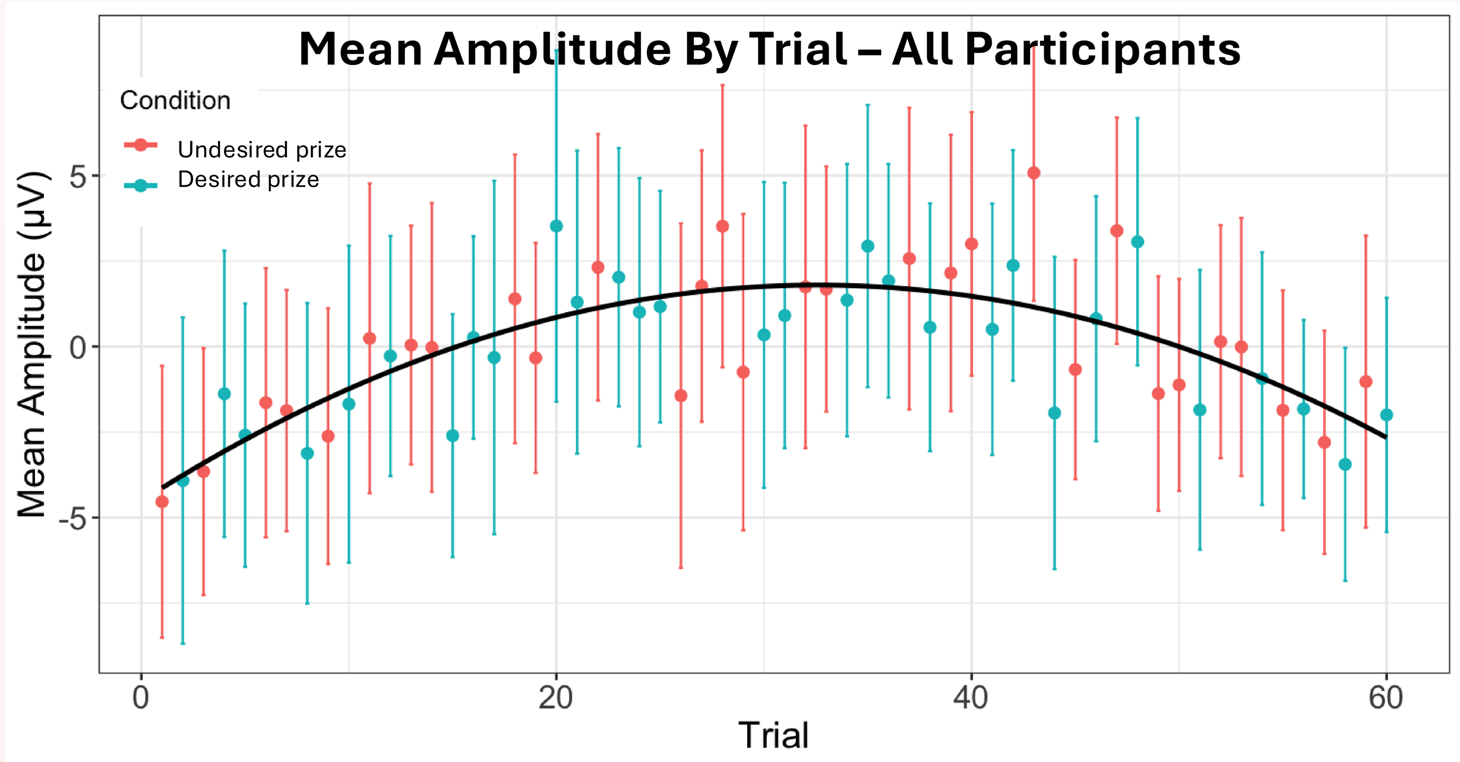


**Figure 2.** Mean amplitudes by trial across all participants by condition

**Table 2.** Mean Amplitude by Condition, Trial, and Age

| Predictor | Estimate (β) | SE | df | t | p |
|---|---|---|---|---|---|
| Intercept | -4.33 | 1.52 | 93.93 | -2.84 | .006 |
| Condition (pos+) | -0.40 | 0.36 | 4257 | -1.12 | .261 |
| Age (centered) | -0.14 | 0.14 | 91.46 | -0.98 | .328 |
| **Trial** | 0.38 | 0.04 | 4257 | 9.05 | **< .001** |
| **Trial²** | -0.006 | 0.001 | 4257 | -8.75 | **< .001** |
| **Age × Trial** | 0.011 | 0.004 | 4257 | 2.94 | **.003** |
| Age × Trial² | -0.00010 | 0.00006 | 4257 | -1.72 | .085 |

**Objective 2:** Age significantly moderated the linear effect of trial, *β* = 0.011, *p* = .003.

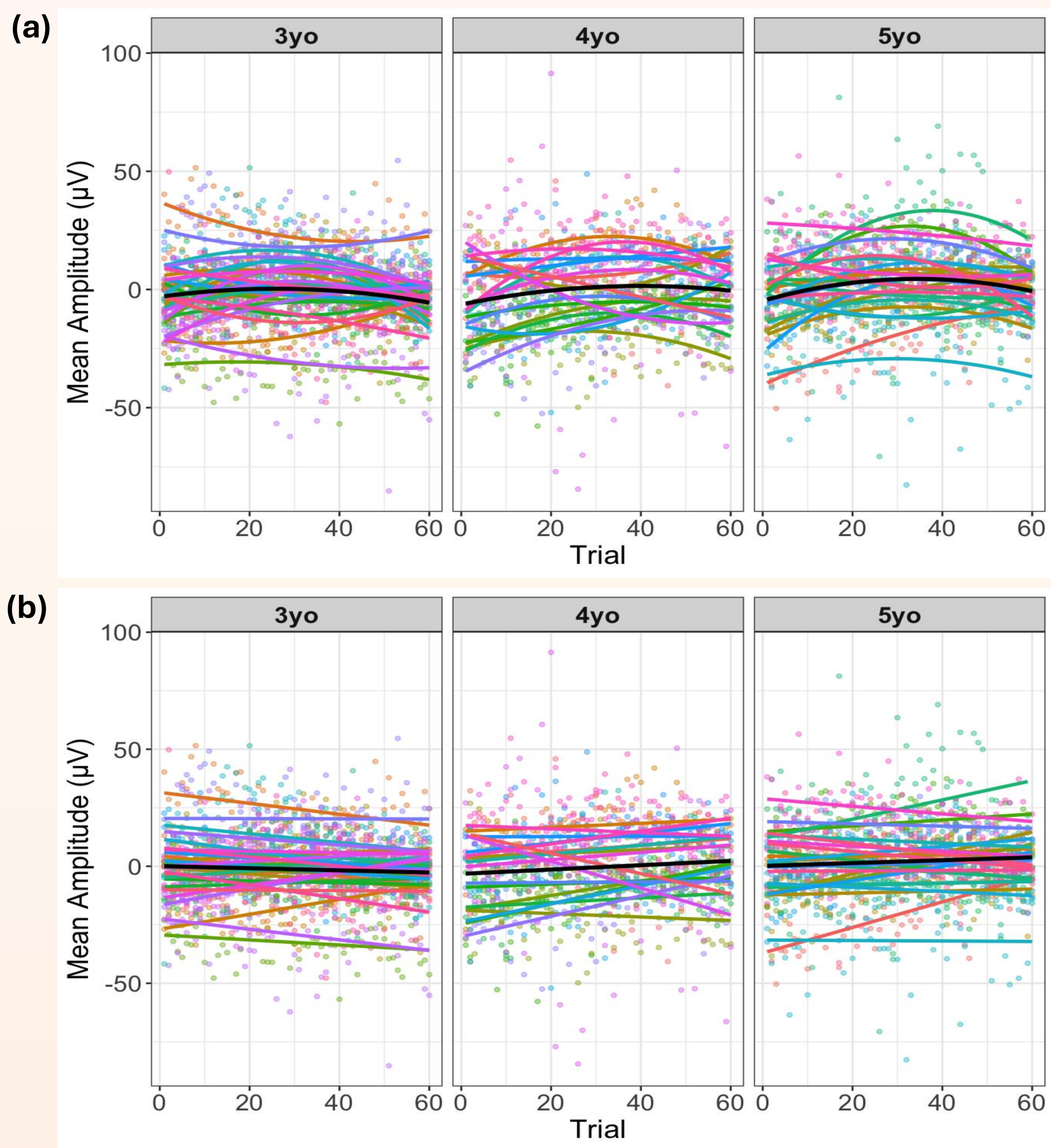


**Figure 3.** Mean amplitudes across trials by condition with (a) quadratic and (b) linear fit. Individual fit lines (color) and grand averages (black) are shown.

## Future Directions

- Examine mechanisms underlying trial differences such as attention, perception, motivation, with button-press-based variables (e.g., reaction time variability, premature presses, reaction time across trials) or eye-tracking.
- Collect data from autistic children to measure response to reward. Results may reveal differences in reward responsiveness in autistic children, informing the social motivation hypothesis of autism and helping tailor common reward-based interventions to better support engagement and learning.

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