Probability Learning:
Why Toddlers Choose More Like Adults Than Older Children

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Introduction

Probability learning is a crucial ability for mastering key challenges during childhood such as, for instance, language acquisition. The finding that infants as young as 12 months old are sensitive to probabilities based on proportions, suggests that nonverbal probabilistic reasoning is already present in infancy (Denison & Xu, 2014).

In standard probability learning tasks, however, it has been found that older children mainly probability match by choosing options in proportion to their probability of reward (Plate et al., 2018). Yet, maximum rewards are achieved by probability maximizing, exclusively selecting the option with the higher reward probability – which is what very young children tend to do (Derks & Paclisanu, 1967). Why is it that younger children tend to outperform older children in probability learning tasks and probability maximize more like adults?

We propose that the answer may be related to the effort involved in implementing different strategies. Rather than regarding probability maximizing as an optimizing strategy, it might instead serve as a cognitive shortcut requiring low inhibitory control (Jones, 1970) and can be used as a satisficing strategy (Schulze et al., 2020). We examine the age trajectories of choice behavior in a probability learning task to illuminate the mechanism behind probability maximizing in early childhood.

Probability Matching and Maximizing

Consider a parent and their child in the supermarket checkout line where the child spots their favorite candy bar.
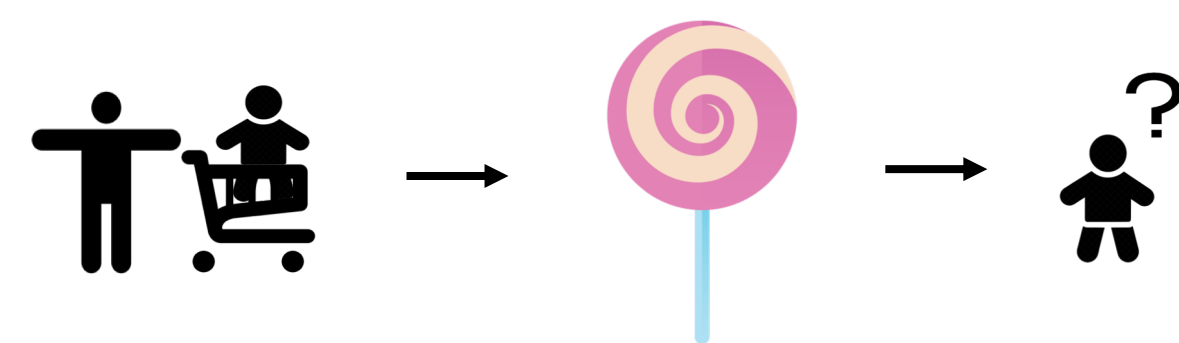

Over many shop visits, the child has learned that throwing a tantrum will get them a candy bar most of the time, whereas remaining calm only rarely leads to success. Which strategy should the child usually choose?

	Throw tantrum	Remain calm
	70%	30%
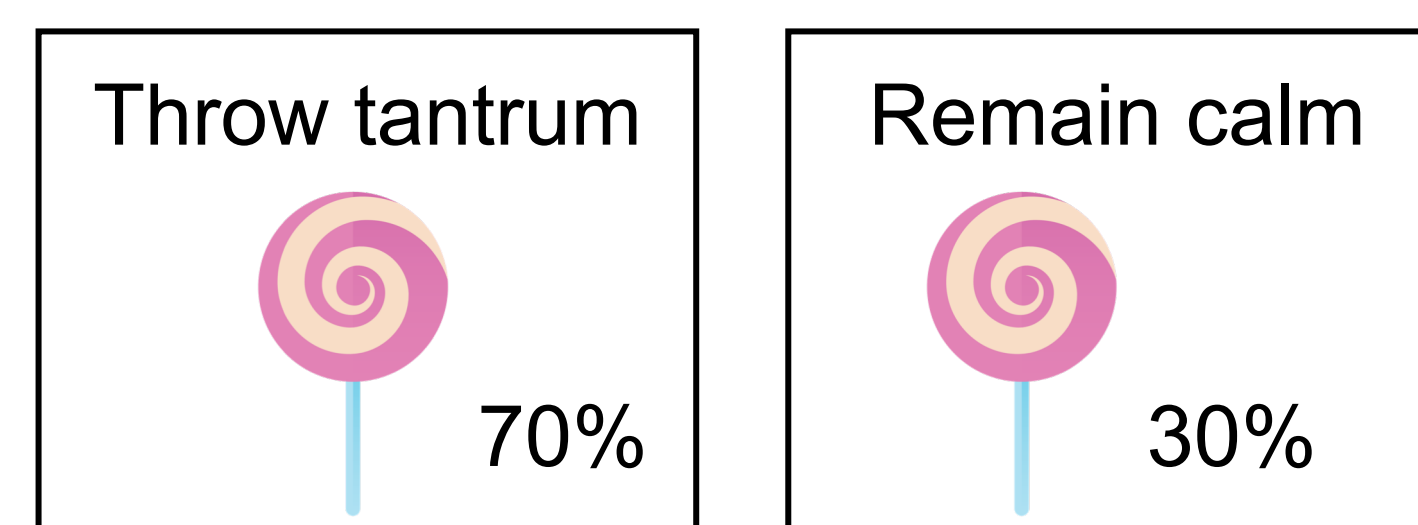
| Choice proportions	Tantrum	Calm	Accuracy
Probability *maximizing*	100%	-	70%
Probability *matching*	70%	30%	58%

Method

- The planned sample size is 40 children and adults per age group (3-4, 6-7, 9-11 years; adults) and condition (N = 320). As of now, we tested 302 participants
- We implemented two reward conditions as a between-subject factor in a child-friendly, standard probability learning task with 100 trials
    - **70-30 condition:** One location was rewarded in 70% of the trials, the other in 30%
    - **50-50 condition:** Both locations were rewarded 50% of the trials

Choice

Behind which house is an animal hiding?

Feedback
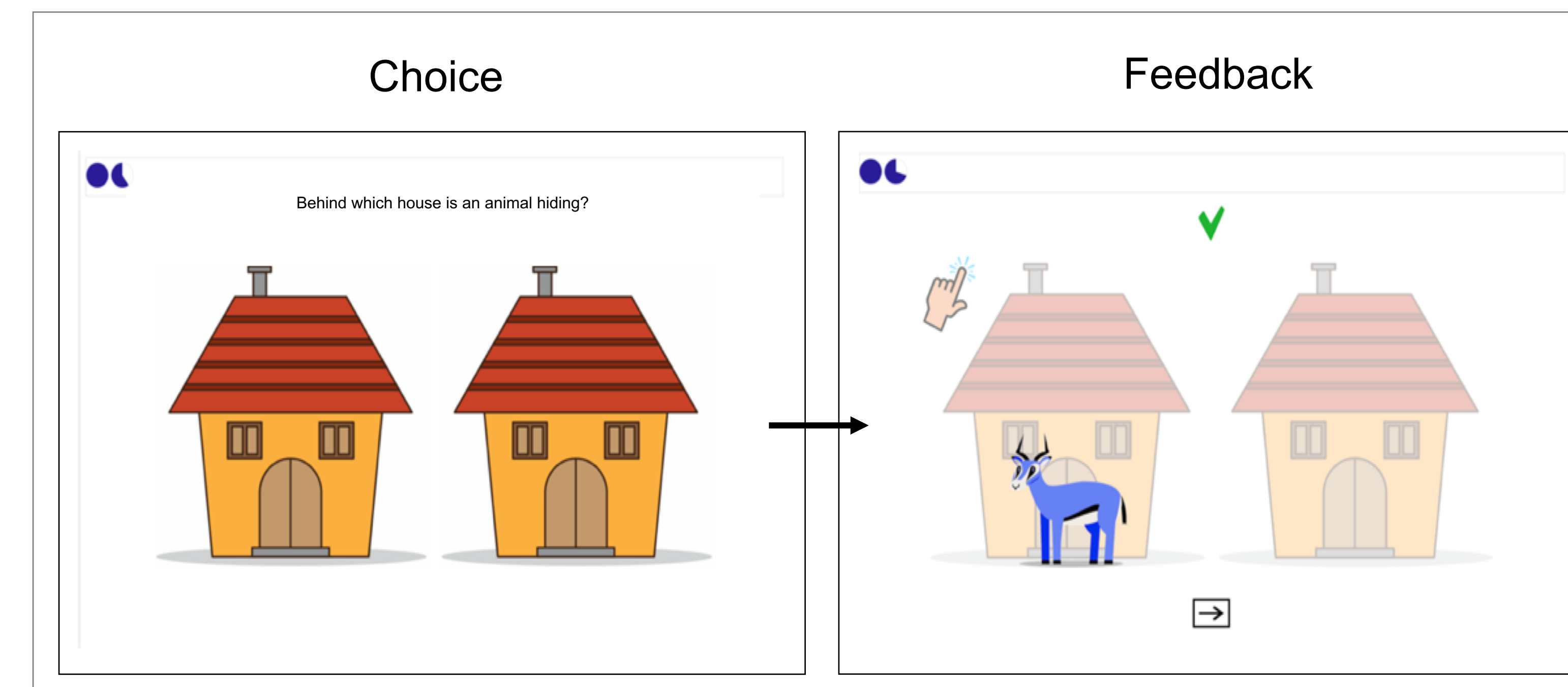
Results

- In the 70-30 condition, there was no difference between age groups in the ability to correctly identify the predominantly rewarded location ("majority location")
- 3-4 year-old children more often persisted with one option than older children and adults, even when both options were rewarded equally often

Proportion of Majority Location Choices per Condition and Age Group
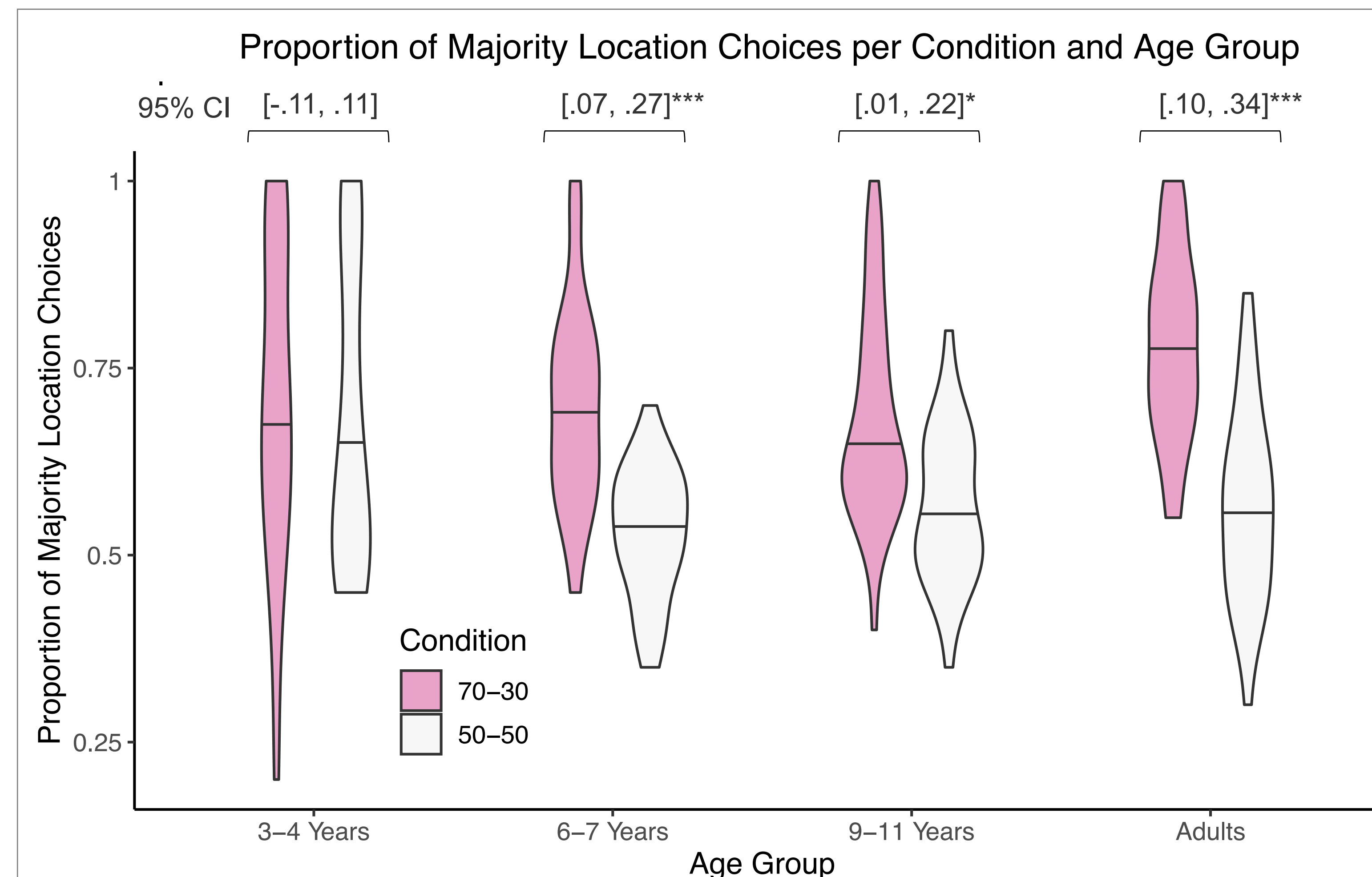
Note. Over the last 20 trials of the task. The "majority location" in the 50-50 condition is the choice location that each participant chose most often throughout the entire experiment. *p < .05, ***p < .001

Results (continued)

- Probability maximizing is more prevalent in young than in older children, while older children probability match more

Probability Matching and Maximizing per Age Group: 70–30 Condition
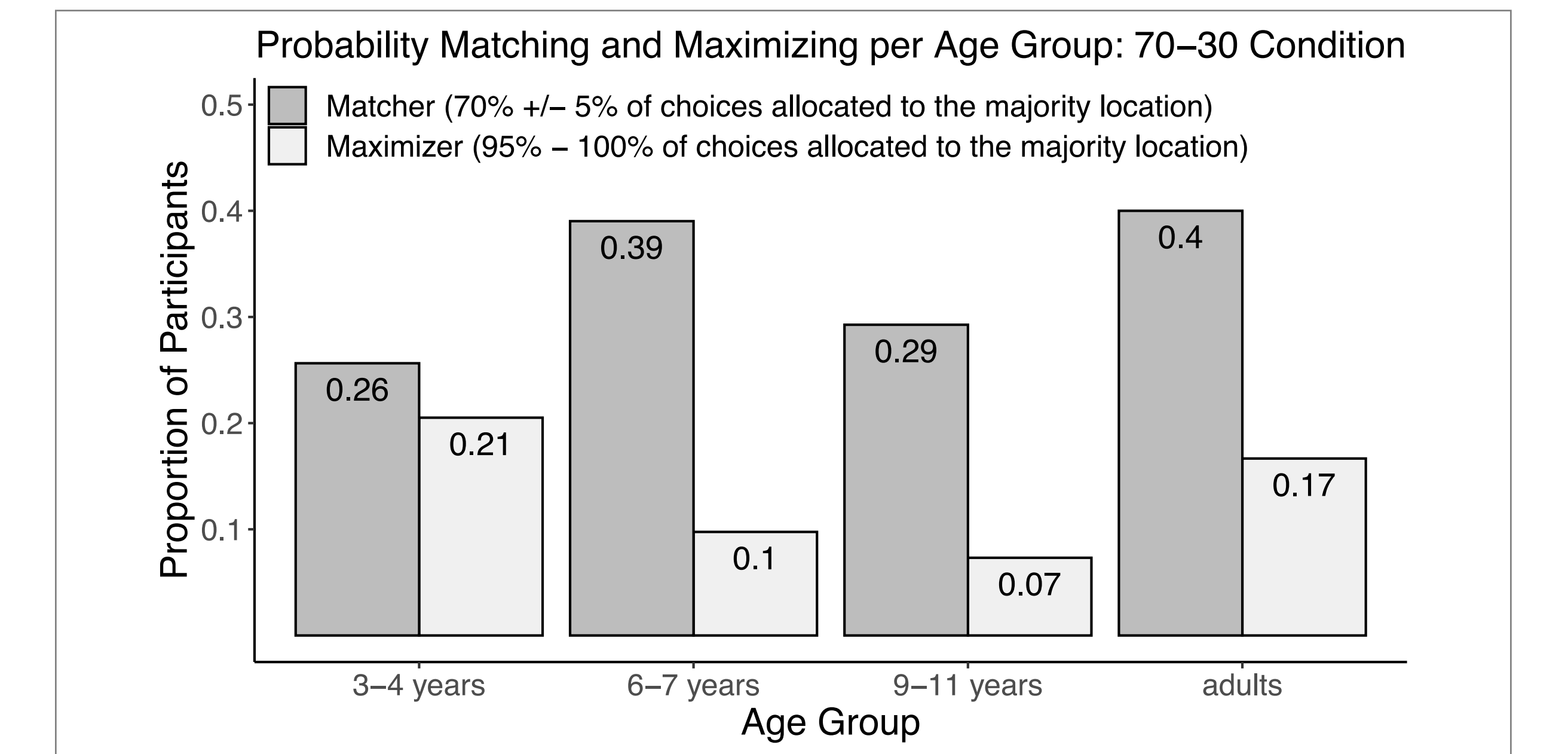
- Win-stay lose-shift as an easily implementable choice heuristic is used by half of the children aged 6-7 years – but to a lesser extent by other age groups

Win–Stay Lose–Shift Use per Age Group: 70–30 Condition
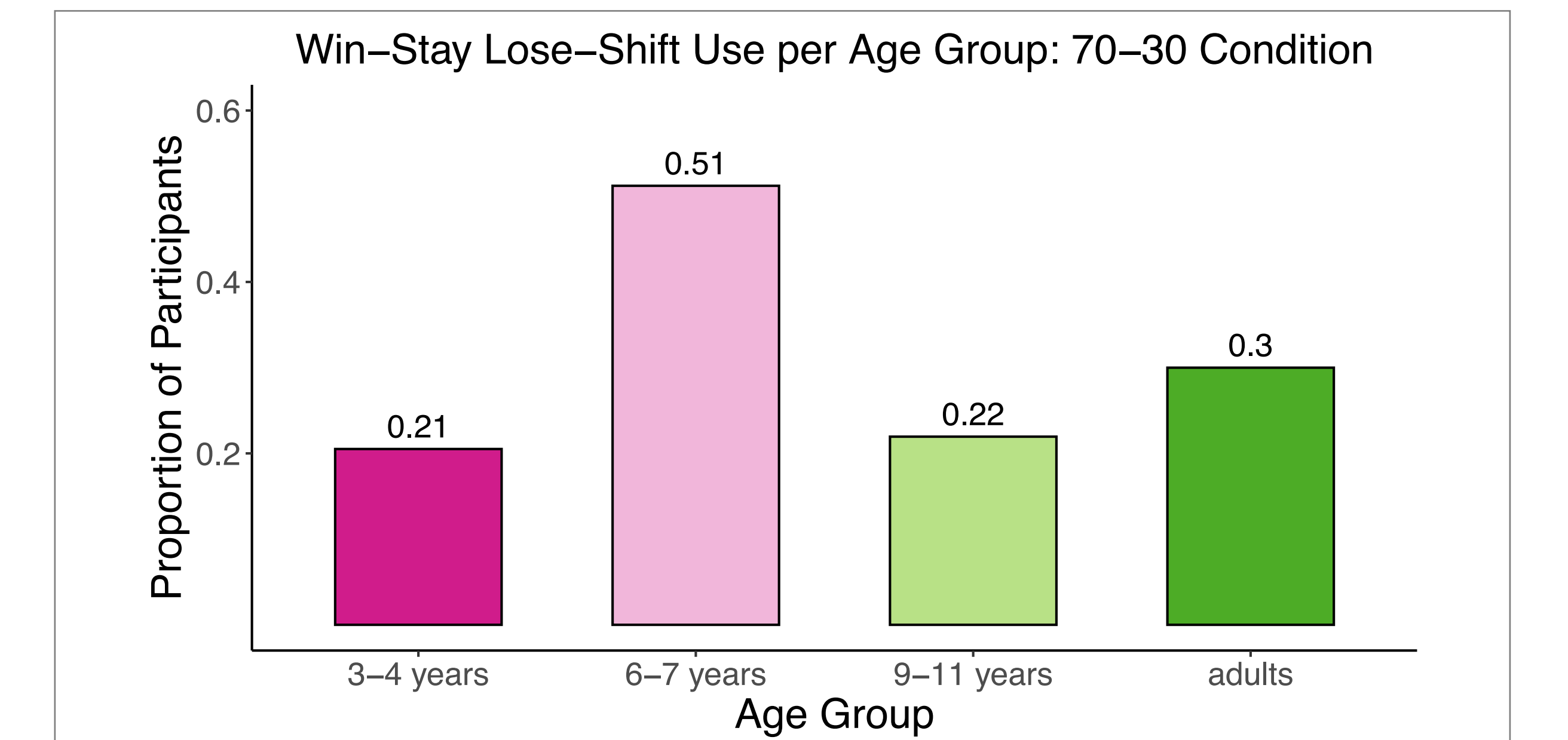
Conclusion

- Probability maximizing is readily implemented by toddlers. The tendency to persist with one choice option, irrespective of whether this option maximizes probability, seems to be a driving factor
- Probability matching and the use of simple heuristics, by contrast, are behaviors that are more often used later in childhood and may serve the goal of wider exploration

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