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Children's understanding of economic demand: A dissociation between inference and choice

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ABSTRACT

Adults infer that resources that become scarce over time are in higher demand, and use this "demand inference" to guide their own economic decisions. However, it is unclear when children begin to understand and use economic demand. In six experiments, we investigated the development of demand inference and demand-based economic decisions in 4- to 10-year-old children and adults in the United States. In Experiments 1–5, we showed children two boxes with the same number of compartments but containing different numbers of face-down stickers and varied the information provided about how those differences arose (e.g. that other children had taken the stickers). In separate experiments, we asked children to buy or trade to get a sticker for themselves or to predict what other children would do. We also asked them which set of stickers they thought the other children had preferred to assess their ability to make a demand inference separately from their own choice. Across experiments, children were able to make a demand inference about children's past preferences by 6 years of age. However, children did not use this demand information when making choices for themselves or when predicting what another child would select in the future. In Experiment 6, we adapted the task for adults and found that adult participants inferred that the set containing fewer resources was in higher demand, and selected the higher demand resource for themselves at rates significantly above chance. The overall pattern of results suggests a dissociation between economic inference and economic decisions during early-to-middle childhood. We discuss implications for our understanding of the development of economic reasoning.

1. Introduction

A mature understanding of economic value requires consideration of other people's preferences and choices. For example, two goods may appear equivalent, but the relative scarcity of one likely reflects higher demand, and thus higher value, to others. In order to draw this conclusion, a person must recognize the difference in quantities and infer that the difference was caused by other people choosing between the same two options. One can then use this "demand inference" to guide one's own choice. Adults consistently use this kind of process when making economic decisions, preferring goods that were once abundant but have become scarce over time when told that other people had previously had the opportunity to select goods, thus providing an economic-demand-based reason for the goods' scarcity (Mittone & Savadori, 2009; Parker & Lehmann, 2011; Robinson, Brady, Lemon, & Giebelhausen, 2016; Van Herpen, Pieters, & Zeelenberg, 2009; Worchel, Lee, & Adewole, 1975). Indeed, adults tend to place higher value on goods that have become scarce over time due to demand (Brock, 1968; Lynn, 1991, 1992). However, it is unclear when children make demand inferences and use them to make their own economic decisions. In the current paper, we investigated the development of demand inferences and decisions under different informational contexts.

Very young children are capable of many of the basic cognitive processes required to understand economic demand. Infants and children notice differences in quantity (e.g. Halberda & Feigenson, 2008; Lipton & Spelke, 2003) and by at least preschool are able to reason about unobserved causes of differences in quantity (Kibbe & Feigenson, 2015, 2017). Infants also infer that non-random arrays of objects are created by intentional agents and not by mechanical processes (Ma & Xu, 2013), and infants who observe a person deliberately select a scarce resource infer that the person intentionally selected that resource (Wellman, Kushnir, Xu, & Brink, 2016).

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Yet despite these early capacities, explicit reasoning about the relationship between economic demand and value appears to emerge much later in development (e.g. Siegler & Thompson, 1998). Early research on the development of children's economic thinking used hypothetical stories to investigate children's explicit reasoning about supply, demand, and resource value. After hearing simple stories involving a lemonade stand, 4-year-olds understood that if more people were thirsty on a hot day, sales of lemonade would increase (Siegler & Thompson, 1998). However, children did not understand that this increase in demand might increase the price (the value) of the product until about 8 years of age (Thompson & Siegler, 2000; Leiser & Halachmi, 2006; though see Huh & Friedman, 2019). Other studies using Piagetian-style interviews found that 4-year-olds believed that the value of an object was determined by its size while 8-year-olds believed that usefulness was the main indicator of value (Berti, Bombi, & Duveen, 1988; Burris, 1983). While these studies may underestimate children's economic competence, they depict a prolonged development of explicit reasoning about the determinants of resource value (Leiser & Halachmi, 2006).

Recent research has focused on whether children use resource quantity as a cue to guide their choices in experimental tasks. For example, when children in Israel and Taiwan were allowed to choose one reward from two types of prizes, one abundant and one scarce, 4- and 5-year-olds selected an abundant reward (Diesendruck, Chiang, Ferera, & Benozio, 2019). By 7 years of age, Israeli children chose the scarce reward but Taiwanese children showed no preference for either scarcity or abundance (see also Ferera, Benozio, & Diesendruck, 2020). Experiments with 4-to 12-year-olds in the United States have found that children tend to avoid scarce resources, preferring variety and abundance, except in specific circumstances (Echelbarger & Gelman, 2017). When children must choose rewards both for themselves and someone else from a choice set of one item of one type and five items of another, they take the scarce item for themselves (Echelbarger & Gelman, 2017; Mittone, Savadori, & Rumiati, 2005, see Diesendruck et al., 2019; Ferera et al., 2020, for evidence that this scarcity preference may be culturally specific). Social pressure in a live setting, when a puppet will choose next from abundant or scarce resources, also increases the preference for scarcity but only among 6-year-olds, not 4-year-olds (John, Melis, Read, Rossano, & Tomasello, 2018). In summary, younger children seem to prefer abundant resources across a range of contexts, but a preference for scarce resources tends to appear later in development, perhaps encouraged by social comparison or competition.

Yet, scarcity alone is not a clear cue of the economic value of a resource. For example, scarcity could reflect a change in supply based on low demand. In order to make the link between scarcity and demand for a resource, one must understand that low relative quantity has resulted *from other people's choices*, thus making the inference that the cause of resource depletion was that other people had valued that resource more. While previous work suggests that adults robustly make this inference (Mittone & Savadori, 2009; Parker & Lehmann, 2011; Robinson et al., 2016; van Herpen et al., 2009; Worchel et al., 1975), it remains unknown whether and when children can integrate information about a resource's relative scarcity or abundance with information about others' choices to make inferences about a resource's value, and whether and when they may use this inference in their own economic decisions.

In the current studies, we tested whether 4- to 10-year-olds (Experiments 1–5) and adults (Experiment 6) could make inferences about resource demand under different contexts in a choice task. In Experiments 1–5, children were shown two boxes with the same number of compartments but with different quantities of stickers in each, thus signaling that there had initially been the same quantity of each type of sticker. Stickers were face down, so that children could not see their design. We then explained that other children had already selected stickers from the boxes, thus providing the demand information without *explicitly* telling children which box other children had preferred. Instead, children had to infer which set of face-down stickers was preferred by incorporating three pieces of information: the fact that the two sets contained different types of stickers, the fact that there are different numbers of empty slots in the boxes (and therefore different quantities of stickers in each box), and the fact that other children had already taken stickers. In doing so, children could determine that the *reason* that the boxes contained different numbers of stickers was that one of the boxes contained stickers that were in higher demand and thus more highly valued. To increase the salience of their decision and place it in an economic context, we either had children "buy" the chosen sticker with a token or trade a sticker to acquire the new one. In Experiment 6, adults completed a similar task online, except that they were told that the items in the boxes were flower seed packets rather than stickers.

We used two measures to examine participants' demand inferences. First, participants were given the opportunity to select a resource for *themselves* from one of the two boxes. After they had made their selection, we asked participants which of the two sets of resources they thought the other participants had liked more. These two measures allowed us to assess whether participants could a) explicitly make a demand inference based on other people's choices and b) implicitly use a demand inference to guide their own behavior. Prior research has not examined these two processes in the same task in children, and there is reason to expect that they may not coincide. In other economic decision tasks, children between 3 and 6 years of age can explicitly state what they and other children should do but do not use that knowledge to guide their own behavior (Blake, 2018; Smith, Blake, & Harris, 2013). One goal of the current study was to determine whether a similar gap between knowledge and behavior exists for children's understanding of economic demand.

We predicted that adults in Experiment 6 would show similar patterns to adults in previous work on the impact of demand on consumer choices (Parker & Lehmann, 2011; Robinson et al., 2016; van Herpen et al., 2009): they would effectively incorporate the differences in the quantities of resources and the information that others had already taken resources, successfully infer that the scarcer resource was in higher demand, and then select the higher demand resource for themselves. Because little is known about how children's knowledge about demand inferences aligns with their own choices, we outline four possible outcomes for the relationship between these two measures. First, children may select a sticker from the higher demand box for themselves, and select the higher demand box when asked what other children preferred. This pattern of results would suggest that children infer that demand for the resource reflects higher value to others and use that information in selecting resources, similar to adults. A second possibility is that children will select the more abundant resource both for themselves and when asked what other children preferred. This pattern of results would suggest that children are not making inferences about resource demand, but may instead be predisposed to select an abundant resource over a scarce one, as observed in previous work (e.g. Echelbarger & Gelman, 2017). A third possibility is that children may show no systematic preferences. A final possibility is that there may be a dissociation between inference and resource selection: children may infer that the scarce resource was preferred by other children, but may not choose the higher-demand resource for themselves. Given the wide age range we are testing (4- to 10-year-olds), we predicted that if the fourth outcome obtained, only older children's choices for themselves would align with their inferences about other children's preferences based on demand.

2. Experiment 1: Buy

2.1. Methods

2.1.1. Participants

Participants were 36 4–10-year-old children (M = 6.26 years, SD = 2.00 years, 17 girls). The age range was determined based on previous work examining children's developing understanding of economic demand across similar age ranges (Beth Leiser & Halachmi, 2006; Siegler & Thompson, 1998; Thompson & Siegler, 2000). Sample size was determined prior to data collection. Children were recruited in the Boston area via public birth records and community recruitment events. One child was identified by their caregiver as Asian, two as Black/African American, 21 as White, eight as belonging to two or more races, and three declined to report. Thirty-one children came from families where at least one parent received a college degree or higher. All children were tested in a quiet laboratory room and received a small gift for their participation.

2.1.1.1. Materials. Children were provided tokens that they could use to purchase stickers. A "token bank" in the form of a black box with a slot on top was used to collect the tokens after children had "purchased" their stickers. The stickers were presented face down in two black boxes with either 4, 9, or 12 compartments. The 4-compartment boxes (13 cm × 13 cm) were used in the Familiarization phase. The 9- (18 cm × 18 cm) and 12- (26 cm × 19 cm) compartment boxes were used in Resource Choice and Demand Inference trials. All stickers were square (4.5 cm × 4.5 cm) and had white backings.

2.1.2. Procedure

Children were seated across from the experimenter at a child-sized table. The experimenter told children that they were going to play a game, in which they would be given tokens that they could use to purchase stickers. The experiment proceeded in three phases: Familiarization, Resource Choice, and Demand Inference.

2.1.2.1. Familiarization. The Familiarization phase was designed to introduce children to the sticker-buying game. The experimenter placed the token bank on the table, and told children that she would show them different boxes of stickers. When they decided which box they wanted to take a sticker from, they could put the token in the bank and select their box. The experimenter placed on the table two 4-compartment boxes, each containing four face-down stickers. Thus, both sticker boxes were full (neither had missing stickers), contained the same number of stickers, and the patterns on the stickers were not visible to children. The experimenter then told children, "Here are two boxes of stickers. This box has one kind of stickers and this box has another kind." She then handed the child a token and said, "OK, here is a token, and I have two boxes of stickers here. Which box would you like to buy from?" After the child had placed the token in the token bank and pointed to the box they wanted to take a sticker from, the experimenter removed the sticker from the box and placed it face down on the table next to her. Children were told that they would receive their stickers once the game was complete.

Since the boxes contained the same number of stickers, and children were given no information about the stickers except that each box contained a different type, we expected that children would select the boxes roughly equally. However, children tended to choose the box on their right more often than on their left (25/36 children chose the box on their right; binomial test $p = .03$). All children used the token to buy a sticker. Fig. 1 depicts a Familiarization trial for Experiment 1.

2.1.2.2. Resource choice. On each of the two Resource Choice trials, children were presented with two boxes containing different numbers of face-down stickers. On one trial, children were shown two 9-compartment boxes, and on the other trial children were shown two 12-compartment boxes, with trial order counterbalanced across children. Regardless of the number of compartments in the boxes, one box always contained 2 stickers (the *higher demand* box) and one always contained 8 stickers (the *lower demand* box) (see *Quantities,* below).

As in the familiarization trial, the experimenter told children that one of the boxes contained one kind of sticker, while the other box contained another kind of sticker. She then told children, "OK, now these boxes used to be full. But other kids were here earlier, and they got to see what these different kinds of stickers look like. Then they got to use their token to buy one." She then handed the child a token and said, "Here is *your* token. Which box would *you* like to buy from?" Once the child had made their selection, the experimenter placed their sticker face down on the table and removed the boxes from the table. This procedure was repeated for the second Resource Choice trial. Whether the smaller quantity was presented on the right or left was counterbalanced across trials and across participants. Children showed no side preference in their selections: children selected the box on their right on 34 of the 72 total trials (binomial test $p = .72$). Fig. 1 depicts an example Resource Choice trial for Experiment 1.

2.1.2.3. Demand inference trials. Following the Resource Choice trials, children completed two Demand Inference trials designed to assess whether children were able to infer other children's preferred stickers from the information provided in the experiment (i.e., the differences in quantities of stickers in the two boxes, and the information that other children had seen and selected stickers already). On each Demand Inference trial, the experimenter placed one of the pairs of boxes back on the table (with children's chosen stickers removed), then asked children, "Which box do you think the other kids liked more?" Note that no matter which box the child had taken a sticker from, the remaining quantities of stickers were still quite different between the boxes (e.g., 1 versus 8 or 2 versus 7). The order in which the box sets were presented for the Demand Inference trials matched the order used for the Resource Choice trials.[1]

We opted to present the above experimental phases in a fixed order (first Resource Choice, then Demand Inference) because we reasoned that asking children to explicitly make a decision about other children's preferences before they had the chance to select their own resource could subsequently bias their choice for themselves. That is, we reasoned that the use of demand information to make a choice for the self is more implicit, while deciding which of two resources is more popular to others makes demand more explicit. We therefore probed children's potentially more implicit use of demand information before obtaining their explicit judgments.

2.1.3. Quantities

Table 1 summarizes the quantities used in each trial. In the Familiarization trial, the boxes each had four compartments and both contained four stickers (each 100% full). In Resource Choice trials, we manipulated the number of stickers in each box and the ratio of stickers to compartments to convey how "in demand" the stickers were. In both Resource Choice trials, one box always contained 2 stickers while the other contained 8 stickers. Thus, one box always contained more stickers than the other. By keeping the total number of compartments constant for each pair of boxes, 9 or 12 total compartments, children could clearly

[1] At the end of the study, we asked children why they made the choice they did in both Resource Choice and Demand Inference trials and coded children's responses. Specific details about the coding scheme and plots for Experiments 1–4 can be found in Figure S2. Overall, children made infrequent reference to demand. The vast majority of children's explanations across experiments referred generically to quantity (e.g. "it has more"), referred to preference (e.g. "because they liked it") or expressed uncertainty (e.g. "I don't know), with only a small percentage of children referring specifically to demand (e.g. "Since the other kids saw, they knew which stickers were better, so I wanted that one"), and the distributions of these explanation types were not different between Resource Choice and Demand Inference trials. Thus, although though children made demand-based choices in Demand Inference trials when asked which stickers other children preferred, their explanations infrequently mention demand. It is possible that children's quantity- or preference-based explanations may have reflected demand, but it was not possible to interpret these explanations as unambiguously demand-based. These data suggest that children may have difficulty articulating the reasons behind their decisions.

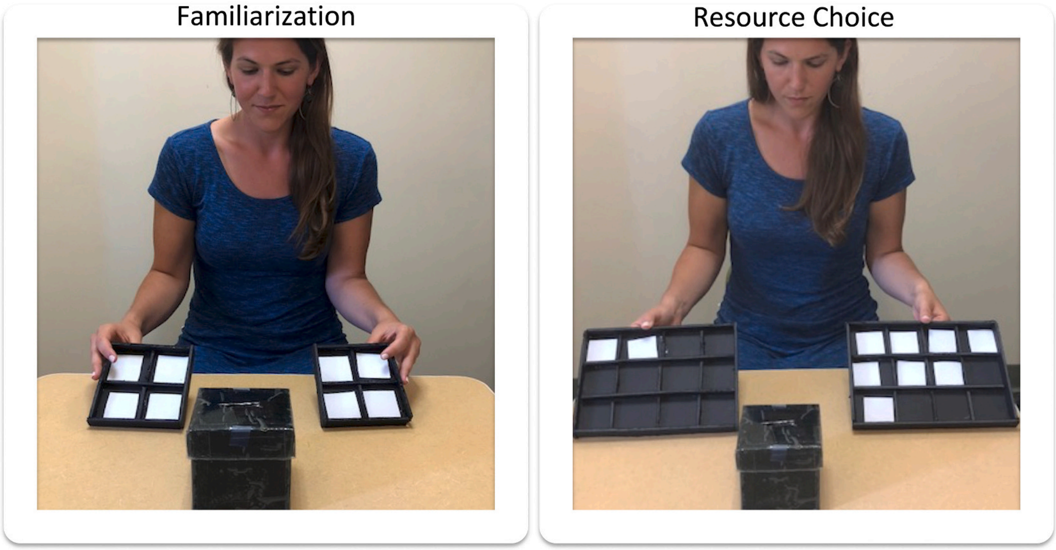

Fig. 1. Familiarization trial (left panel) and a 12-compartment box Resource Choice trial (right panel) from Experiments 1, 2, and 5.

Table 1
Ratios of stickers to compartments (i.e. how “full” each box was) in the Familiarization/Trust Induction trial and the two Resource Choice trials in Experiments 1–6.

	Familiarization (Exps. 1–4, 6)/Trust Induction (Exp. 5)		9-Compartment Box Trial		12-Compartment Box Trial	
	Right	Left	Low Demand	High Demand	Low Demand	High Demand
Ratio stickers to compartments	4:4 (100%)	4:4 (100%)	8:9 (88.9%)	2:9 (22.2%)	8:12 (66.6%)	2:12 (16.6%)

contrast both the quantity of stickers and the number of empty spaces in the pairs of boxes. Thus, demand-based decisions did not depend on children’s understanding of cardinality of number.

Although both trials presented children with a choice between a box with a scarce resource and a box with a more abundant resource, they differed slightly in the evidence they conveyed about other children’s preferences. Children were presented with *more evidence* about other children’s preferences in 12-compartment trials versus 9-compartment trials: 14 total stickers were missing in 12-compartment trials versus 8 missing in 9-compartment trials. The 12-compartment trials thus conveyed information about the choices of a larger sample of children. In addition, children were presented with overall *less variability* in the other children’s decisions in 9-compartment trials versus 12-compartment trials. In 9-compartment trials, out of 8 empty compartments only one child had “taken” a sticker from the low demand box (12.5%) whereas in the 12-compartment trials, out of 14 empty compartments four children had “taken” from the low demand box (28.6%). In subsequent analyses, we compared children’s response patterns on 9-compartment and 12-compartment trials before conducting analyses on children’s overall choices.

2.1.4. *Coding and analyses*

Our main dependent variable was which box children selected in each trial. Selecting the higher demand box was coded as 1 and selecting the lower demand box was coded as 0. Sessions were video recorded, and children’s responses on each trial were coded from video recordings by two independent observers. Observers agreed on all trials.

All statistical analyses were conducted with R statistical software (version 3.6.2, R Core Team, 2019). Data were analyzed using Generalized Linear Mixed Models (GLMMs) with a binary response term (1 or 0) using the package ‘lme4’ (Bates, Maechler, Bolker, & Walker, 2014). Each participant received two types of trials: two Resource Choice trials and two Demand Inference trials. For each trial type, there was one trial with 9-compartment boxes and one trial with 12-compartment boxes. In the analyses for each experiment, we first examined models that contrasted all four trials and found that the 9-compartment and 12-compartment trials did not differ within each trial type (Resource Choice and Demand Inference). Therefore, all models described below used a Trial Type variable which nested the 9- and 12-compartment trials under each type. This allowed a direct comparison of the two trial types while retaining the repeated measure structure. We used the ggpredict function (ggeffects package) to determine if and when the two trial types diverged using predicted probabilities and confidence intervals based on the model predictions.

In all models, participant ID was fit as a random intercept to control for repeated measures. A baseline model with only the random intercept was compared to a full model which included the primary variables of interest, Age (continuous), Trial Type (Resource Choice, Demand Inference), and their interaction plus two design variables, Order of presentation of the 9- and 12-compartment boxes and Side of the high demand box (left or right), and Gender (female, male). The drop1 command was used to assess the contribution of individual variables to the model fit based on the model AIC and a likelihood ratio test (LRT) (see Bolker et al., 2009; Venables & Ripley, 2002). The reduced models always included Age and Trial Type and the interaction plus any significant variables from these tests. Interaction effects were examined using data visualization tools in R (ggplot2, interactions) for the final models to determine whether 95% confidence intervals overlapped a) for each trial type and b) with chance level decisions (50% predicted values).

Data for all studies can be found at: https://osf.io/2c6qu/.

2.2. *Results*

We first compared a random intercept-only model with a full model as described above. The full model showed an improved fit over the baseline model (likelihood ratio test, LRT, $\chi^2 = 80.75$, $p < .001$). We the used the drop1 command to test the variables in the full model. The interaction of Age x Trial Type improved the model fit (LRT, $\chi^2 = 5.48$, $p < .05$) but none of the other variables did (see Table 2). The reduced

Table 2
Estimated coefficients and 95% CIs of fixed effects in Generalized Linear Mixed Models predicting children's selection of the higher-demand box (= 1). Baseline levels were set as follows: Trial Type = Inference, Order = 12 box first, Condition = Untrustworthy.

	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
Intercept	−2.87[a]	−1.44	−3.42[a]	−6.12[a]	−2.15[a]
	[−5.46; −0.27]	[−3.23; 0.35]	[−5.85; −0.99]	[−9.27; −2.97]	[−3.51; −0.78]
Age	0.25	0.19	0.50[a]	0.91[a]	0.27[a]
	[−0.13; 0.63]	[−0.05; 0.43]	[0.14; 0.85]	[0.45; 1.36]	[0.09; 0.45]
Trial Type	−5.54	2.46[a]	−1.56	2.70[a]	−0.85
	[−17.97; 6.89]	[0.03; 4.89]	[−5.04; 1.93]	[1.59; 3.80]	[−3.67; 1.97]
Age x Trial Type	2.06	−0.34[a]	0.59		0.55[a]
	[−0.68; 4.80]	[−0.67; −0.00]	[−0.02; 1.20]		[0.08; 1.02]
Order		−0.73[a]			
		[−1.43; −0.03]			
Condition					−0.45
					[−1.04; 0.13]
AIC	123.93	194.71	151.36	136.68	283.41
BIC	138.78	212.45	166.14	148.56	305.30
Log Likelihood	−56.96	−91.36	−70.68	−64.34	−135.70
#Trials	144	142	142	144	284
#Participants	36	36	36	36	72
Var: ID (Intercept)	2.23	0.00	1.55	2.64	0.00

[a] 0 outside the confidence interval.

model thus included only the main effects and interaction of Age and Trial Type. Fig. 2a shows the interaction effect based on the model output. By 5 years of age, children were more likely to select the higher demand box when asked the Demand Inference question ("Which box do you think the other kids liked more?"; predicted probability = .96, 95% CIs [0.78, 0.99]) compared to the Resource Choice question ("Which box would you like to buy from?"; predicted probability = .16, 95% CIs [0.07, 0.34]). With age, children were more likely to select demand-based choices for themselves but this effect remained within chance levels (Age: $\beta = 0.25$, 95% CIs [−0.13, 0.63], Table 2, Fig. 2a). Individual children's Demand Scores are presented in Fig. S1 in Supplemental Materials.

2.3. Discussion

The results of Experiment 1 suggest that children are capable of making demand inferences, but that they do not use this inference when making their own choices. At all ages, children stated that other children liked the scarce stickers more, integrating the fact that one set had a lower quantity and the information about other children buying stickers before them to infer higher demand. Nevertheless, children did not seem to take this information into account when making a choice about which sticker to choose for themselves. Indeed, younger children in Experiment 1 were overall more likely to select the box with the greater number of stickers, suggesting a general bias toward the larger quantity that decreased with age. Overall, the results suggest that children at all ages interpreted the cause of different quantities of stickers in terms of demand, but tended to not base their own selections on resource demand.

However, one alternative interpretation of children's beliefs about other children's preferences has nothing to do with demand. They may simply expect other children to prefer scarce resources without considering how the differences in quantities arose. To evaluate this possibility, in Experiment 2, children were again given the opportunity to purchase a sticker with a token (as in Experiment 1), but were *not* told about other children selecting stickers before them. We again asked them to buy a sticker and this time asked them which sticker they thought other children *would* prefer.

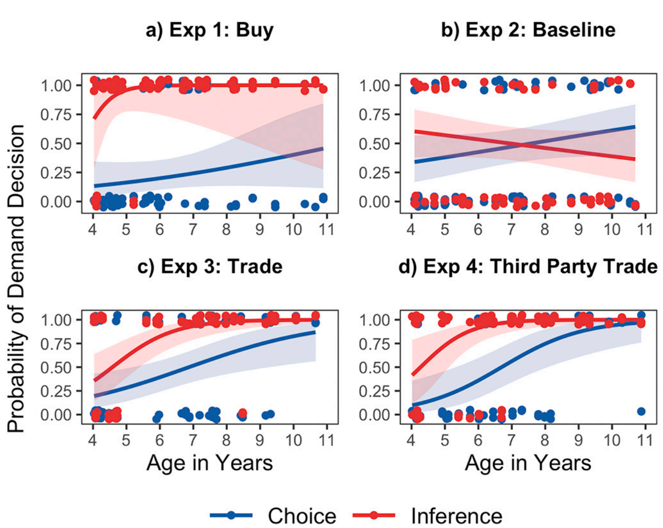

Fig. 2. The probability that children selected the higher demand box (more empty compartments) based on model output for the first four experiments. Children's choices for themselves (or a future child in Experiment 4) are shown in blue and their demand inferences are shown in red. Dots represent individual children's responses on each trial. Shaded areas are 95% confidence intervals based on model estimates. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

3. Experiment 2: Baseline

3.1. Methods

3.1.1. Participants

Participants were 36 children ages 4-to-10-years-old (M = 6.97 years; SD = 2.10 years; 20 girls). The age range and sample size were selected to match Experiment 1. Five children were identified by their caregiver as Asian, one as Black/African American, 21 as White, and nine were identified as belonging to two or more races. All 36 children came from families where at least one parent received a college degree or higher. All children were tested in the laboratory and received a small gift for their participation.

3.1.2. Materials and procedure

The materials and procedure were similar to Experiment 1. Familiarization proceeded as in Experiment 1 (23/36 children chose the box on the right, binomial test $p = .13$).

Resource Choice trials were similar to Experiment 1, except that children were *not* told that other children had previously chosen stickers. Instead, children were simply shown the two boxes of stickers and asked which box they would like to buy a sticker from. As in

Experiment 1, side of placement of the boxes was counterbalanced across trials and across participants. Children selected the box on the right on 40 out of 72 total trials (binomial test $p = .41$).

For the Demand Inference trial children were asked which boxes other children "would like better". Children's responses were coded as in Experiment 1. Two independent observers recorded children's responses, with no disagreement.

3.2. Results

We ran the same regression models for Experiment 2 as we did for Experiment 1. The full model showed some improvement over the intercept only model but this was not a significant effect (LRT, $\chi^2 = 10.87$, $p = .092$). We conducted the rest of the analyses to generate a complete comparison with the other models (see Table 2, Fig. 2b). Ultimately, this analysis confirmed that children's decisions for both trial types were at chance levels across ages.

The main purpose of conducting the Baseline experiment was to compare the results to those of Experiment 1, in which children were given information about other children having selected stickers before them. We thus conducted a combined analyses including Experiment as a categorical variable and testing the three-way interaction between Experiment x Age x Trial Type. A full model improved the fit over an intercept only model (LRT, $\chi^2 = 92.14$, $p < .001$). The drop1 command showed that the three-way interaction improved the model fit (LRT, $\chi^2 = 10.65$, $p < .01$). The three-way interaction term was significant in this final model (Table S1). To examine the interaction of Experiment and Trial Type, we compared the predicted probabilities using the testInteractions function from the "phia" package. These results showed that children's choices for themselves did not differ between the experiments ($\chi^2 = 0.71$, $p = .40$) but that their inferences about other children's preferences revealed a stronger tendency to select the higher-demand resource in Experiment 1 (Buy) compared to Experiment 2 (Baseline), ($\chi^2 = 7.02$, $p < .05$). In addition, there were no differences between the Resource Choice and Demand Inference trials for Experiment 2 ($\chi^2 = 0.53$, $p = .47$) whereas Demand Inference choices were significantly higher than demand-based Resource Choices for Experiment 1 ($\chi^2 = 8.54$, $p < .01$).

3.3. Discussion

The results of Experiment 2 provide two insights into the results from Experiment 1. First, when making their own choices, children in both experiments tended to avoid the box with fewer stickers, preferring to select the box with more abundant stickers. This abundance bias decreased with age across both experiments, with the oldest children's selections for themselves tending toward chance levels. Given the similar performance in both versions of the experiment, it appears that children are not using the information about the potential source of the differences in quantity, that other children had bought stickers before them, when it is provided. However, children are not ignoring that information completely. When asked to infer other children's preferences, children used this information when it was provided and concluded that other children had preferred the currently scarce resource. When demand information was removed in Experiment 2, children did not use the difference in quantities to draw the same conclusion.

Why might children in Experiment 1 not use information about resource demand when choosing for themselves? One possibility is that children may not have had sufficient motivation to do so. In Experiment 1, children were endowed with an arbitrary token and were given the opportunity to purchase a sticker. Regardless of their choice, the outcome of each decision is that children will always become one sticker richer. Thus, while children may have understood that one set of stickers was preferred by other children, they may not have been highly motivated to use that information in choosing a sticker for themselves.

In Experiment 3, we examined this possibility by attempting to make children's sticker choice more costly. Children were again presented with two sets of stickers, were told that other children had traded stickers before them, and were then asked to choose a sticker for themselves. However, instead of purchasing the sticker with a token, children were endowed with three stickers at the beginning of the experiment, and were told that they could trade one of their stickers for one of the stickers in the boxes. Thus, children had to decide whether to take a chance to trade their own (known) stickers for the unknown stickers in the boxes. While previous work suggests that children have more difficulty reasoning about the relationship between trading and value in hypothetical story scenarios (Beth Leiser & Halachmi, 2006), children also tend to place a higher value on items that they are given (the "endowment effect"; Harbaugh, Krause, & Vesterlund, 2001; Gelman, Manczak, & Noles, 2012; Hood, Weltzien, Marsh, & Kanngiesser, 2016). We reasoned that, if children decided to trade their stickers, they may be more motivated to use information about resource demand to select the best possible sticker.

4. Experiment 3: Trade

4.1. Methods

4.1.1. Participants

Participants were 36 4–10-year-old children ($M = 6.57$ years; SD = 1.9 years; 17 girls). Sample size and age range were selected to match Experiment 1. Four additional children participated but were excluded due to experimenter error (1) or refusal to trade stickers during test trials and therefore failing to produce the dependent variable (3). Three children were identified by their caregivers as Asian, two as Black/African American, 22 as White, eight as belonging to two or more races, and one declined to report. Thirty-one children came from families where at least one parent received a college degree or higher. All children were tested in the laboratory and received a small gift for their participation.

4.1.1.1. Materials. The materials used in Experiment 3 were the same as in Experiment 1, except that the token bank and tokens were removed and three yellow smiley face stickers were used.

4.1.2. Procedure

Children were seated across from the experimenter. The experimenter placed the three yellow smiley-face stickers face up on the table and told children that they were going to play a game. She said, "I'm giving you these three stickers. Now I'm also going to show you some boxes of other stickers and you get to decide if you want to trade your sticker for better stickers that are in these boxes." Children were told that the boxes contained "better" stickers in order to motivate them to trade, but they were not shown what stickers were in the boxes. Children were endowed with three stickers since they would be given three opportunities to trade, once during Familiarization and twice during the two Resource Choice trials.

The Familiarization and Resource Choice phases proceeded as in Experiment 1. During Familiarization, children were shown two 4-compartment boxes, each containing four stickers, and were told that they could trade one of their stickers for a sticker in one of the boxes. All but one child chose to trade their sticker during the Familiarization trial. As in Experiment 1, during Resource Choice trials children were told that other children had seen the stickers, and had traded their stickers for stickers in the boxes. Children were then given the opportunity to trade one of their stickers in order to select a new sticker from one of the boxes. The Demand Inference trials proceeded as in Experiment 1, in which children were shown the pairs of boxes and asked which stickers they thought the other children liked better.

Two independent observers recorded children's responses. There was no disagreement between observers. Coding was done as in

Experiments 1 and 2. One child chose to end the experiment before the Demand Inference trials, so this child contributed data to the Resource Choice measure only.

4.2. Results

Following the same analyses as for the first two experiments, the full model showed improvement over the intercept only model (LRT, $\chi^2 = 39.03$, $p < .001$). The drop1 command showed that the interaction of Age and Trial Type (LRT, $\chi^2 = 3.95$, $p < .05$) improved model fit but the other variables did not. The reduced model thus included only the main effects and interaction of Age and Trial Type. The interaction of Age and Trial Type is shown in Fig. 2c. Demand-based resource choices increased with age (Age: $\beta = 0.50$, 95% CIs [0.14, 0.85], Table 2, Fig. 2c) and exceeded chance levels only by 10 years of age (predicted probability = .83, 95% CIs [0.54, 0.95]). Demand inferences also increased from 4 years of age (predicted probability = .35, 95% CIs [0.14, 0.63]) to 10 years of age (predicted probability = 1.00, 95% CIs [0.95, 1.00]), exceeding chance levels by 6 years of age (predicted probability = .82, 95% CIs [0.64, 0.92]).

Because Experiments 1 and 3 had a similar design, we conducted a combined analysis in order to double the sample size and improve the possibility of detecting small effects. The full model included a three-way interaction of Experiment, Age, and Trial Type as well as the three other variables. This model improved the fit over an intercept-only model (LRT, $\chi^2 = 124.67$, $p < .001$). The drop1 command showed that none of the variables improved the model fit, including the three-way interaction term. We next ran a model with a two-way interaction between Age and Trial Type and left Experiment as a main effect. Now the drop1 command showed that only the interaction term improved model fit (LRT, $\chi^2 = 7.02$, $p < .01$). The reduced model included the interaction term as well as the main effect of Experiment as a control variable (Table S1). The combined data show children younger than 7 years of age choose the box with a greater number of items for their own choice: 6 years of age, predicted probability = .30, 95% CIs [0.18, 0.45]. By 7 years of age, the confidence intervals for the choice trial overlapped with the chance level of 0.5 (predicted probability = .38, 95% CIs [0.25, 0.54]) and choices did not exceed chance levels for older children. By contrast, by 5 years of age, children inferred that other children preferred the scarcer items: predicted probability = .80, 95% CIs [0.65, 0.90]).

4.3. Discussion

In Experiment 3, we reasoned that asking children to give up a sticker in order to obtain a "better" sticker would induce them to make choices based on the difference in demand for the two boxes. Although demand-based decisions exceeded chance levels by 10 years of age when children made a trade (Experiment 3), a direct comparison to Experiment 1 (Buy) revealed no differences in children's decisions. Similar to Experiment 1, younger children were more likely to choose the box with more items (abundance) and older children were at chance in their decisions. Moreover, as in Experiment 1, with age, children were likely to infer that the children who had chosen stickers before them preferred the stickers in the box with fewer.

The results from the experiments so far suggest a dissociation between children's inferences about resource demand and their choices for themselves. By around age 6, children can robustly infer other children's preferences after observing two different quantities and hearing that other children had seen and selected stickers already. Yet, despite the highly consistent demand inferences drawn by children in Experiments 1 and 3, these children also consistently demonstrated chance performance in choosing a resource for themselves.

It is possible that, since children were told that both boxes contained better stickers, they may still not have been sufficiently motivated to use others' preferences to make their own choice. That is, perhaps trading was not much more costly than "buying". However, another potential reason that children may not use demand inference for their own decisions is that they may "fail in the moment" of the decision due to arousal (Smith et al., 2013). That is, facing the sticker choice may increase excitement and interfere with the cooler process of making the inference from quantity to demand and using that knowledge to guide one's choices (Metcalfe & Mischel, 1999). If this is the case, then children should integrate information about resource demand into their choices when they are removed from the immediate arousal of making a choice for themselves. To test this, we altered the choice task so that children were asked to predict what another child would choose. We then asked the inference question about other children's past choices that lead to differences in quantity. If the same gap between children's choice and ability to infer demand appears, then this effect is not likely to be due to in-the-moment arousal when faced with a choice for themselves, but instead is more likely a general tendency not to link demand inference to current (or future) choices, made by self or others.

5. Experiment 4: Third Party Trade

5.1. Methods

5.1.1. Participants

Participants were 36 4-to-10-year-old children (M = 6.84 years, SD = 1.91 years; 16 girls). Age range and sample size were selected to match the previous experiments. Nine children were identified by their caregivers as Asian, four as Black/African American, 18 as White, three as belonging to two or more races, and two declined to report. Thirty-one children came from families where at least one parent received a college degree or higher. All children were tested in the laboratory and received a small gift for their participation.

5.1.2. Materials and procedure

The materials and procedure were similar to Experiment 3. During Familiarization, children were told that they could trade a sticker for one of the stickers in the boxes. 31/36 children chose to trade their sticker. Children selected the right and left boxes at roughly equal rates (16/31 children chose the box on the right; binomial test $p = 1.0$).

Following Familiarization, the experimenter told children, "Another kid, just like you, is coming in to the lab later to play my trading game. I want you to help me guess how s/he will trade her/his sticker." The pronouns used matched the reported gender of the participant. The experimenter proceeded with the Resource Choice trials, telling children that other children had been in the lab previously, had seen the stickers, and had gotten to choose. Children were encouraged to select the box they thought the future child would likely select. Thus, children did not receive a sticker during Resource Choice trials in this experiment; they were only asked to predict a future child's choice. The side of the higher demand box was counterbalanced across trials and across children. Children did not show a side preference in their selections (children selected the right-side box on 39/72 trials, binomial test $p = .56$).

Demand Inference trials proceeded as in Experiments 1 and 3, in which children were asked which of the two boxes other children (who had previously selected stickers) had preferred. Two independent observers recorded children's responses, with no disagreement.

5.2. Results

Following the same analyses as for the prior experiments, the full model showed improvement over the intercept only model (LRT, $\chi^2 = 45.98$, $p < .001$). The drop1 command showed that only Age (LRT, $\chi^2 = 15.46$, $p < .001$) and Trial Type (LRT, $\chi^2 = 26.01$, $p < .001$) improved model fit, but the interaction did not. For the reduced model we retained the main effects of Age and Trial Type and dropped the other variables. (The interaction of Age and Trial Type is shown in Fig. 2d to provide a complete comparison with the other experiments.) Demand-based resource choices increased with age (Age: $\beta = 0.91$, 95% CIs [0.45; 1.36], Table 2), and by 8 years of age exceeded chance levels (predicted probability = .76, 95% CIs [0.53, 0.90]). By 9 years of age, the confidence intervals for choices for the future child overlapped with inferences for (past) others (Choice: predicted probability = .89, 95% CIs [0.67, 0.97]; Inference: predicted probability = .99, 95% CIs [0.96, 1.00]). Demand inferences also increased between 4 years of age (predicted probability = .55 95% CIs [0.25, 0.82]) and 10 years of age (predicted probability = 1.00, 95% CIs [0.97, 1.00]), exceeding chance levels by 5 years of age (predicted probability = .75, 95% CIs [0.51, 0.90]).

To determine whether children's decisions in Experiment 4 were different from those in Experiment 3, we combined the two data sets and ran regressions that included a three-way interaction between Experiment, Age, and Trial Type. The full model showed improvement over the intercept only model (LRT, $\chi^2 = 84.75$, $p < .001$), but the drop1 command showed that no predictors improved the model. We next ran a model that kept Experiment as a main effect and included the interaction between Age and Trial Type. This model showed improvement over the intercept only model (LRT, $\chi^2 = 83.88$, $p < .001$), and the drop1 command showed that the interaction term alone improved model fit. The reduced model included Experiment as a control variable and the main effects and interaction of Age and Trial Type (Table S1). The main effect of Experiment was not significant, nor were interactions with this term, which suggests that children made the same decisions for the future child in Experiment 4 as they did for themselves in Experiment 3.

5.3. Discussion

The results of Experiment 4 provide a third replication of the finding that, by 5–6 years of age, children can make a demand inference regarding other children's past preferences based on two pieces of information: the relative scarcity of a resource and knowledge that other children had selected stickers earlier. As in Experiments 1 and 3, children were not explicitly told which set of stickers other children had preferred, but instead had to use available information to make an inference about resource demand. However, although children made this demand inference, children were not likely to use resource demand when predicting what a future child would choose; children's tendency to choose the higher-demand resource increased with age, but did not exceed chance levels until age 9–10 years. This may reflect that, with age, children were more likely to incorporate demand information into their predictions about what others will choose, or children overall may simply have selected for another child what they would have chosen for themselves. Indeed, the pattern of responses for predicting a third party's choices closely resembled children's choices for themselves in Experiment 3. Regardless, these results suggest that children's tendency to not incorporate demand inferences when making their own choices is not due to the high arousal nature of the task.

Perhaps children did not take other children's preferences into account in making decisions about resource selection (either for themselves or when predicting what others will do) because they lacked information about other children's *motivations* for their choices. Children may be able to infer that other children liked a resource better, but without more information about why they made those decisions they may not believe that past preferences should guide current or future decisions. For example, it may be that the other children were collecting a particular type of sticker or that they have different, or worse, taste than oneself. Children who are provided information about the rationale of children's choices may be more likely to incorporate that information into their own decisions or to imitate others' actions (Poulin-Dubois, Brooker, & Polonia, 2011; Sobel & Kushnir, 2013).

In Experiment 5, we examined whether children may be more likely to incorporate other children's preferences into their resource selection decisions when given information about the *trustworthiness* of the other children's preferences. Children were randomly assigned to one of two conditions. In the *Trustworthy* condition, children were first given information that suggested that the other children selected good stickers over poor ones (and thus, their taste in stickers should be trusted). In the *Untrustworthy* condition, children were first given information that suggested that the other children selected poor stickers over good ones (and, thus, their taste in stickers should not be trusted). The experiment then proceeded as in Experiment 1, in which children were shown two boxes of face-down stickers, were told that the other children had already chosen stickers, and were then given the opportunity to buy a sticker from one of the two boxes. We reasoned that children in both conditions may be more motivated to incorporate resource demand into their choice for themselves, since doing so would maximize their chances for getting a good over a bad sticker (by either going with the group in the *Trustworthy* condition, or by going against the group in the *Untrustworthy* condition). That is, we predicted children's pattern of responses would be moderated by whether or not they believed they could trust other children's taste in stickers.

6. Experiment 5: Buy + Trust

6.1. Method

6.1.1. Participants

Participants were 72 4–10-year-old children[2] (mean age = 7.01 years; SD = 1.93 years; 31 girls). Children were randomly assigned to the *Trustworthy* condition ($n = 36$) or the *Untrustworthy* condition ($n = 36$). Four children were identified by their caregiver as Asian, eight as Black/African American, 44 as White, 11 as belonging to two or more races, and five declined to report. Sixty-four children came from families where at least one parent received a college degree or higher. An additional four children participated but were excluded from analysis due to experimenter error (3) or failure to pass an attention check during the Trust Manipulation phase (1; see below). All children were tested in the laboratory, and received a small gift for participating.

6.1.1.1. Materials. Materials were similar to Experiment 1, except that a set of "good" stickers (shiny rainbow stars) and a set of "boring" stickers (plain white circles) were used during Trust Manipulation (see below).

6.1.2. Procedure

Children were told that they would play a game in which they could buy stickers with tokens provided by the experimenter (as in Experiment 1). The experimenter introduced children to the token box. The experiment then proceeded in three phases: Trust Manipulation, Resource Choice trials, and Demand Inference trials.

6.1.2.1. Trust manipulation. Children were shown two 4-compartment boxes, each containing four face-down stickers. The experimenter told children, "Other kids were here earlier, and they got to see what these different kinds of stickers look like. They thought *this* box [pointing to one of the boxes] had better stickers." To ensure children had paid attention and understood, she then asked children to point to the box that other children had thought contained better stickers. The side of the "preferred" box was counterbalanced across children.

With the stickers still face down, the experimenter then asked children to choose a box to purchase a sticker from. Interestingly, when making their choices, children did not appear to take into account the explicit information provided by the experimenter about other children's preferences: 37/72 children (51%) chose a sticker from the box that the other children were said to have preferred (binomial test $p =$

[2] We first collected data from 36 7–10-year-old children, and then collected a second sample of 36 4–6-year-old children.

.91); children's choices were not different across conditions Fisher's exact test $p = .64$). This pattern is consistent with the results of the Resource Choice trials of Experiments 1 and 3. In Experiment 5, even when children were *explicitly* told which box other children preferred, they did not use that information to make their choice.

After children had chosen, the experimenter then gave children information about how trustworthy the other children were in their preferences by revealing the stickers in each box. In the *Trustworthy* condition, the box that other children said had better stickers contained "good" stickers (shiny rainbow stars), while the other box contained "boring" stickers (plain white circles). In the *Untrustworthy* condition, the box the other children said had better stickers contained boring stickers, while the other box contained the good stickers. Participants were then asked which type of stickers they themselves thought was better. In the *Trustworthy* condition, 30/36 children (83%) selected the good (and preferred) stickers (chance = 50%; binomial test $p < .001$), and in the *Untrustworthy* condition, 35/36 children (97%) selected the good (and non-preferred) stickers (binomial test $p < .001$). Children's responses did not differ by condition (Fisher's exact test $p = .11$).

6.1.2.2. Resource choice & demand inference. The Resource Choice trials proceeded similarly to Experiment 1. Children were presented with boxes containing different quantities of face-down stickers, were told that those same children they had just been told about had gotten to see these stickers as well and had chosen stickers to take home. Children were then asked to choose a sticker to buy. Note that, unlike during the Trust Manipulation phase, children were *not* explicitly told which box the other children preferred. Instead, just as in Experiments 1, 3, and 4, other children's preferences had to be inferred based on the differences in quantities across the boxes and the information that other children had selected stickers already. As in Experiments 1–4, after children made their selection, the experimenter removed a sticker from the chosen box and placed it on the table, face-down; thus, children did not receive any information about sticker quality during Resource Choice trials.

Demand Inference trials proceeded as in Experiment 1 (see Fig. S4 for children's explanations for their choices), except after the two Demand Inference trials, children also were asked whether they thought the other children had "good taste in stickers". In the *Trustworthy* condition, 28/36 children responded "yes", 2/36 responded "no", and 6/36 responded with uncertainty (e.g. "I don't know"). Children's responses were more evenly distributed in the *Untrustworthy* condition, with 19/36 children responding "yes", 10/36 responding "no", and 7/36 responding with uncertainty (*Trustworthy* vs. *Untrustworthy* χ^2 $p < .005$). Interestingly, while children in the Untrustworthy condition were less likely than children in the Trustworthy condition to say that other children had good taste, their responses were not completely reversed. We speculate that children may have been less willing to cast aspersions on other children's taste.

Coding was done as in the above experiments. Two independent coders recorded children's responses on each trial; coders agreed on all trials.

6.2. Results

The analyses followed the same approach as for the prior experiments but added Condition (Trustworthy, Untrustworthy) as a between-subjects variable. The full model included a 3-way interaction of Age x Trial Type x Condition plus Order and Gender (side information was integrated with order). This showed an improved fit over the intercept only model (LRT, $\chi^2 = 106.28$, $p < .001$). The drop1 command showed that none of the variables improved model fit, but the 3-way interaction alone was tested as opposed to 2-way interactions. We next tested full models with 2-way interactions of Age, Trial Type and Condition and again used the drop1 command. These models revealed that only the Age X Trial Type interaction improved the model fit (LRT, $\chi^2 = 6.41$, $p < .05$). Condition was retained in the model as a key design variable but Order and Gender were dropped. The reduced model thus included Age, Trial Type, Condition and the interaction of Age x Trial Type. The interaction effect for each condition is shown in Fig. 3 for comparison with the other experiments. By 5 years of age, children in both the Trustworthy (predicted probability = .75, 95% CIs [0.61, 0.85]) and Untrustworthy (predicted probability = .66, 95% CIs [0.50, 0.79]) conditions made demand-based inferences when asked what other children preferred. However, they did not make demand-based choices for themselves and favored the box with more items at younger ages: Trustworthy, 6 years of age (predicted probability = .37, 95% CIs [0.27, 0.49]); Untrustworthy, 7 years of age (predicted probability = .33, 95% CIs [0.23, 0.44]). Choices became more demand-based with age, but did not exceed chance levels. Fig. S3 shows the distributions of children's demand scores in both conditions.

6.3. Discussion

In Experiment 5, by age 5, children inferred which of two resources was in higher demand after being shown different quantities of stickers and being told that children had selected some of the stickers already. As in Experiments 1, 3, and 4, in the test trials, children were not told explicitly which resource other children preferred. Rather, they had to infer this information given the quantities presented and information that other children had already taken stickers.

However, children again did not use this information to guide their selection of a resource for themselves. This effect occurred at two points in Experiment 5. First, in the Trust Manipulation trials, children were explicitly told which stickers other children had preferred and then got to choose a sticker for themselves. Despite acknowledging other children's preferences, they did not use this information when making their own choice. This suggests that children's tendency not to use demand information in their own decisions in Experiments 1, 3, and 4 was not likely due to the order in which we asked the questions (i.e. first asking them to make a choice, then asking them to judge which stickers were preferred by other children), since children chose at chance even after

Fig. 3. The probability that children selected the higher demand box (more empty compartments) based on model output for Experiment 5 in the Trustworthy (left panel) and Untrustworthy (right panel) conditions. Children's choices for themselves are shown in blue and their demand inferences are shown in red. Dots represent individual children's responses on each trial. Shaded areas are 95% confidence intervals based on model estimates. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

being explicitly told which set of stickers the other children preferred. Second, children were then given information about how trustworthy other children's preferences were. In the *Trustworthy* condition, prior to the Resource Choice trials, children saw that other children preferred good stickers over boring ones. In the *Untrustworthy* condition, the opposite was true. We reasoned that children may be incentivized to use a demand inference when selecting a resource for themselves if that choice could result in either a good or a boring sticker. We found instead that children selected the higher- and lower-demand boxes at roughly equal rates, just as they had done in the previous experiments.

Together, the results of Experiments 1–5 suggest a dissociation between children's inferences about resource demand and their selection of resources for themselves. These results contrast with previous work with adults that suggests that adults readily incorporate inferences about resource demand into their choices for themselves (Brock, 1968; Lynn, 1991, 1992; Mittone & Savadori, 2009; Parker & Lehmann, 2011; Robinson et al., 2016; van Herpen et al., 2009; Worchel et al., 1975). For example, wine buyers infer that a particular wine on a mostly empty shelf is in higher demand than a wine on a more full shelf, and are more likely to purchase that wine (van Herpen et al., 2014).

In order to test whether adults would show demand-based resource choice behaviors in the current paradigm, we used an adapted version of our task. In Experiment 6, conducted online, adults viewed still images of the stimuli used in Experiments 1–5. Adults were told that each box contained a different kind of flower seed packet rather than different kinds of stickers. As in Experiment 1, adults were told that other people had already purchased flower seed packets from the boxes, and they were then given the opportunity to choose which box they would like to purchase a seed packet from. Participants were also asked the demand inference question for others' choices. We predicted that adults would infer that the box with more empty slots contained seed packets that were in higher demand, and would select the higher demand seeds for themselves. We further predicted that adults would not show a gap between their own demand-based choices and their inferences for others' choices.

7. Experiment 6: Adults buy

7.1. Methods

7.1.1. Participants

Participants were 61 adults (M = 39.49 years; SD = 5.55 years, range = 28.32 to 55.64 years). The planned sample size was 36 participants to match the sample size of Experiments 1–4. However, due to a coding error, counterbalancing of Side and Order did not occur until after 36 participants had been tested. An additional 28 participants were then tested to add the 3 other combinations of Side and Order. Adults were caregivers of children in our child participant database and were recruited via email. Three additional adults were caregivers of children who had previously participated in one of the other experiments presented in this manuscript (Experiments 1–5); these adults were removed from the data set. We did not collect demographic data from adult participants, but their demographic makeup is likely to be similar to the children in Experiments 1–5. Adults were tested online and could choose to receive flower seed packets by mail for their participation (42 adults chose this option).

7.1.1.1. Materials. This experiment was conducted online using Qualtrics software. Stimuli consisted of photographs of the physical stimuli used in Experiment 1 (see Fig. 4). The boxes were labeled "Box A" and "Box B" in red text on the images. Participants made their choices by clicking corresponding radio buttons labeled Box A or Box B. While the images were of the sticker stimuli used in Experiments 1–5, adults were told the items in each box were face-down flower seed packets, rather than stickers.

7.1.2. Procedure

After agreeing to participate, adults were sent a link to the online study through the Qualtrics platform. At the beginning of the study, adults read the following written prompt: "Imagine you are starting a new flower garden. I'm going to show you some boxes of seed packets and you get to choose which box to buy a seed packet from. One seed packet costs one dollar ($1), so I am going to give you a dollar to use. When you choose which box you want buy a seed packet from, you can click on one of the choices below the image, and I'll put your dollar in

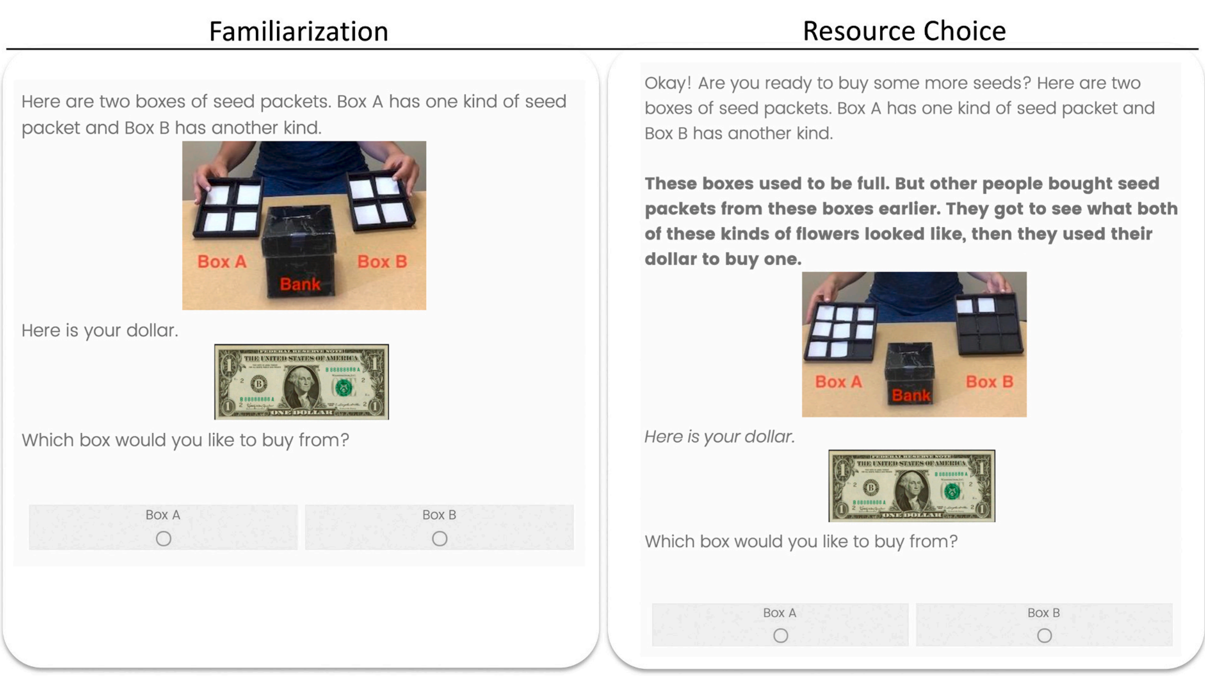

Fig. 4. Familiarization trial (left panel) and a 9-compartment box Resource Choice trial (right panel) from Experiment 6.

the bank. At the end of the survey there will be an opportunity to include your mailing address so we can mail you the seed packets you've purchased." We included language about moving the dollar into the bank to match the structure if Experiment 1.

7.1.2.1. Familiarization. As in Experiment 1, adults first saw two identical boxes, each with four compartments containing four face-down items (i.e., "flower seed packets", see Fig. 4, left panel). Text above the boxes read, "Here are two boxes of seed packets. Box A has one kind of seed packet and Box B has another kind." Adults selected a box by clicking one of two radio buttons labeled "Box A" or "Box B". Although the boxes were identical, when faced with the arbitrary choice between them, participants tended to choose Box A (39/61 participants; binomial test, $p = .02$).

7.1.2.2. Resource choice. The Resource Choice trials were closely matched to those of Experiment 1. On each of the two Resource Choice trials, adults saw still images of two boxes containing different numbers of face-down white items. As in the familiarization trial, adults were informed that one of the boxes contained seed packets of one type of flower, while the other box contained seed packets of another type of flower. Participants were then given the following information: "These boxes used to be full, but other people bought seed packets from these boxes earlier. They got to see what both of these kinds of flowers looked like, then they used their dollar to buy one". Adults saw an image of a dollar and were prompted: "Here is your dollar. Which box would you like to buy from?" Again, adults selected a box by clicking the radio button next to the words "Box A" or "Box B".

Adults completed two Resource Choice trials, with the boxes and quantities used identical to those in Experiments 1–5. The side of the boxes and order of presentation of the trials was counterbalanced across participants.

7.1.2.3. Demand inference trials. As in Experiments 1–5, following the Resource Choice trials, adults completed two Demand Inference trials. On each Demand Inference trial, adults were shown an image of one of the pairs of boxes from the Resource Choice trials. Text beneath the image read, "Why did you pick Box [X] and not Box [Y]?" (participants' actual responses were filled in by the Qualtrics program). Participants typed their responses in an open-ended text box. Participants were then prompted to choose, "Which box do you think other people liked more?", by selecting a radio button next to the words "Box A" or "Box B". Finally, adults were asked, "Why do you think other people liked that box more?" Participants again responded by typing into an open-ended text box. The order in which the box sets were presented for the Demand Inference trials matched the order used for the Resource Choice trials.

7.1.2.4. Coding. Qualtrics was programmed to automatically score the participants' choices on the Resource Choice and Demand Inference Trials. Selecting the higher demand box was coded as 1 and selecting the lower demand box was coded as 0.

7.2. Results

In all models, participant ID was fit as a random intercept to control for repeated measures. A baseline model with only the random intercept was compared to a full model which included the primary variables of interest, Age (continuous), Trial Type (Resource Choice, Demand Inference), and two design variables: Order of presentation of the 9- and 12-compartment boxes and Side of the high demand box (left or right). Note that the models for this experiment do not include the interaction of Age and Trial Type because we tested adults to examine a mature state in the task. Age was included as a control variable. Model fit was assessed based on the model AIC and a likelihood ratio test (LRT).

We first compared a random intercept-only model with a full model as described above. The full model showed an improved fit over the baseline model (likelihood ratio test, LRT, $\chi^2 = 46.79$, $p < .001$). We used the drop1 command to test the contribution of the individual predictors in the full model: only Trial Type was significant (LRT, $\chi^2 = 41.90$, $p < .001$). We retained Age in the model as a control variable and dropped Order and Side. The main effect of Trial Type was significant ($\beta = 6.24$, $p < .001$) and Age was not significant (($\beta = -0.05$, ns). However, the coefficient for Trial Type was too large to interpret, likely due to near complete separation of the data by Trial Type: adults made demand-based decisions for 94% of the Inference trials and 71% of the Choice trials. To obtain a better estimate of the difference between the Choice and Inference trials, we summed the two Choice trials and the two Inference trials for each participant (range: 0 to 2) and conducted a paired *t*-test. The results showed a significant difference between the two trial types: $t = -4.23$, df $= 60$, $p < .001$, 95% CI [−0.68, −0.24].

While adults tended to select the higher demand box more often in Demand Inference trials compared with Resource Choice trials, adults' demand scores for Resource Choice trials were significantly above chance (one-sample t-test: $t = 13.17$, $p = .0001$, 95% CI [0.61, 0.82]. Forty out of 61 adults (65%) selected the high demand box on both trials, 14 selected the lower demand box on both, and 7 chose the high demand box on one trial and the low demand box on the other trial (see Fig. S5 for distributions of adults selections for both trial types). To gain insights into adults' choices, we explored adult's explanations for their choices in the Resource Choice trials. Unlike children, who largely referred generically to quantity ("there's more") or preference ("I just liked that one better"), the vast majority of adults' explanations were demand-based, specifically referring to others' choice history in explaining their own choice (e.g. "I figured they were the prettier flowers since most people liked those - and that many people can't be wrong, right?!"; see Fig. S6). Furthermore, five adults who selected the lower-demand box for themselves also explicitly mentioned that their choices were driven by a desire for uniqueness (e.g. "Fewer people chose that so I thought it would be nice to have a flower that fewer people had in their gardens"; Fig. S6). While qualitative, these results may suggest that adults use demand inferences to make different kinds of choices for themselves, at least under the conditions tested here.

7.3. Discussion

Adults showed a clear preference for the higher-demand box both for their own Resource Choice and for the Demand Inference trials. Despite this shift to a preference for demand-based options, adults were still more likely to select the high demand box when asked what others preferred than for their own choice. These results suggest that adults use demand inferences in making their own choices, consistent with previous work (Brock, 1968; Lynn, 1991, 1992; Mittone & Savadori, 2009; Parker & Lehmann, 2011; Robinson et al., 2016; van Herpen et al., 2009; Worchel et al., 1975), but the dissociation between inference and choice persists into adulthood and may be partially explained by some adults' preference for uniqueness.

8. General discussion

Across six experiments, we investigated children's and adults' ability to infer resource demand, and their ability to use that information when selecting a resource for themselves. Three main findings emerged. First, by 6 years of age, children could consistently infer other children's preferences for one resource over another. The difference in resource quantity alone was not sufficient for children to make this demand inference; rather, children had to be told that other children had already selected items before them, thus allowing them to integrate social information with the difference in quantities (Experiments 1 & 2). Second, children's own choices did not align with what they believed about other children's preferences; children either preferred the more abundant resource, or chose at chance. This dissociation between knowledge about other's preferences and one's own choice occurred both when children were asked to buy (Experiments 1 & 5) or trade (Experiment 3) for the item. Before age 10, children did not select the higher-demand resource at rates above chance even when they were explicitly told which resource other children liked more (Experiment 5, Trust Manipulation trials) and when shown that the other children tended to prefer very high or very low quality stickers (Experiment 5, Resource Choice trials). Adults, on the other hand, selected the higher demand resource for themselves at rates significantly above chance, and the majority chose the higher demand option for both their own choice and their inference about other's choices (Experiment 6). Third, children did not make the connection between choices and preferences for other children as well. When asked to predict what another child would choose, thus removing themselves from the impact of the decision, they did not use past preferences as a guide to future choices (Experiment 4). That is, children did not expect other children to use demand information to guide their choices either.

Scarcity alone is not sufficient for children to infer the economic value of a resource. Scarcity may arise from a reduction in supply due to low demand, or may not have a clear cause. In fact, children tend to prefer abundance over scarcity except in certain circumstances (Diesendruck et al., 2019; Echelbarger & Gelman, 2017). When asked to choose a reward from a set of one sticker or a set of ten stickers, Israeli 4-year-olds selected the abundant resource, and 7-year-olds selected the scarce resource (Diesendruck et al., 2019; see also Ferera et al., 2020). In the same study, Taiwanese 4- and 5-year-olds also preferred abundance, but 7-year-olds showed no preference. In the US, 4- to 12-year-olds also preferred an abundant resource over a scarce one, unless children had to select stickers for themselves and someone else at the same time (Echelbarger & Gelman, 2017). The key information added in the latter case was social and likely competitive. Knowing that another child would also get a prize induced the inference that the scarce item was more valuable. In line with this explanation, 6-year old German children also selected a scarce resource over an abundant one when puppet partners would be choosing a prize next (John et al., 2018).

The current study extends these results by showing that children can *infer* other people's preferences from the quantities of resources available and the knowledge that people had taken the resources previously. By 6 years of age, children made the "demand inference" that the prior children preferred the more scarce resource, but only when they were given a potential cause for the difference in quantities of the resources – namely, that both resources were once abundant and had become scarce over time as other children selected resources. Indeed, when asked what other children would prefer based on scarcity and abundance alone, children were at chance in their responses, suggesting that the social explanation of resource depletion over time is critical for demand reasoning, as it is in adults (Mittone & Savadori, 2009; Parker & Lehmann, 2011; Robinson et al., 2016; van Herpen et al., 2009; Worchel et al., 1975). Siegler and Thompson (1998) found that, around age 4, children expected that a protagonist selling a product (e.g. lemonade) would sell more of the product when it was in high demand (e.g. on a hot day), reasoning forwards about the consequences of demand on a potential supply. Our task required children to reason backwards from scarcity to *infer* that a currently depleted resource must have been preferred by others, which may be a later-developing skill. The age at which children begin to robustly make the link between demand and value in our task is consistent with previous work suggesting that by age 6 children effectively incorporate other sources of information, including effort expended to obtain resources, into their valuations of resources (e.g. Benozio & Diesendruck, 2015). Further work is needed to understand sources of developmental change in children's ability to infer demand from quantity and social information; for example, children's successful inferences may be driven by more domain general development of reasoning abilities or executive functions, or more domain specific development of understanding of economic relations between people and things.

However, despite the ability to make a demand inference about other children's past choices, children were much less likely to select the higher-demand resource for themselves (unlike adults). This finding proved quite robust, appearing even when children were told explicitly that other children preferred one sticker type over another. Why did children decline to select the higher-demand resource? Children's choices are not likely to be due the arousing nature of being faced with making a decision for themselves, since children also did not predict other children's choices based on the same information (Experiment 4).

One possible explanation for children's choices for themselves concerns the presence of social pressure in the moment. In the current series of studies, children were given the relatively low-stakes task of selecting stickers for themselves in a non-competitive experimental context, after being told that other children had participated in a similar task. By contrast, in John et al. (2018) in which children were tasked with selecting an item from a set of one resource or a set of many resources (without any causal history information), potential competitors were present and also about to make a selection. This competitive scenario may have driven up the value of the scarcer item for older children; a rare item may be more desirable when possessing it also means that someone else will not possess it. It also is possible that observing other children making selections would increase the salience of the demand information for children's choices for themselves: while in our experiments children successfully made the "demand inference", by presenting other children's choices as a fait accompli, this approach may have diminished the importance of using that information in driving a decision. Another possibility is that the identity of the other choosers could impact children's choices. For example, if children are told that their friends had previously selected stickers (rather than strangers), this may make the demand information more salient and children may be more likely to use this information in their decisions.

Future work is needed to determine the conditions under which children integrate social economic reasoning into their own decisions. Future work also is needed to identify the extent to which the dissociation we observed would obtain across cultures or would follow the same developmental trends we observed here (Diesendruck et al., 2019). For example, children in our U.S. sample may have been more likely to value independence or nonconformity, which may have influenced their choices for themselves (as indeed a handful of adults explicitly did, Fig. S6). Thus, different cultural values may shape different developmental patterns of economic choice.

Our findings also suggest that the ability to infer resource demand improves significantly with age. While younger children tended not to integrate information about other's past choices with information about differences in quantity to infer economic demand, older children robustly did so. Children's choices of a resource for themselves also varied as a function of age. In line with previous work (e.g. Diesendruck et al., 2019; Echelbarger & Gelman, 2017; John et al., 2018), we found that younger children had a bias toward abundance for their own choices, which held regardless of whether or not they were given information that would allow them to infer the social cause of that abundance. By around age 6, we found that children could make demand inferences about other peoples' decisions and began the shift toward the higher-demand option for themselves. Given that older children were more likely to select the high-demand resource more often than the younger children, successful demand inference may help children to override the bias toward abundance. However, this possibility should be taken with caution because despite an increase in demand-based choices with age, children only exceeded chance levels in one experiment. By adulthood, demand inference and resource choice became more aligned because resource choices clearly favored the higher-demand option. However, a dissociation between own choice and inference for others remained, suggesting that these two processes may never completely merge, at least under the conditions tested here.

Taken together, these age-related differences suggest a potential developmental timeline for children's understanding of economic demand. In early childhood, children have a "more is better" bias that is not grounded in the social factors that influence resource depletion or selection. By around 6 years, children begin to understand the social causes underlying resource depletion (our studies) and are influenced by at least some social forces governing resource selection (i.e. competition: John et al., 2018). However, children at this age are nevertheless not yet willing or able to integrate their inferences about economic demand into their own decisions about resource selection, nor do they expect others to use this information in their decision. By middle-childhood to adulthood, information about resource demand is more readily integrated into economic decisions (Experiment 6; Worchel et al., 1975; Mittone & Savadori, 2009; van Herpen et al., 2009; Parker & Lehmann, 2011; Robinson et al., 2016). However, the mechanisms underlying these developmental shifts remain unclear. One possibility is that, as children develop, situations in which economic reasoning is required occur more often in children's lives, as in competition for rewards with peers or a desire to conform with peers. Inferences about how economic demand drives value may become more automatic and integrated with one's own decisions as children gain experience with these kinds of scenarios. It is also possible that some children may be using demand inferences in their own choices, but children as a whole are not doing so systematically. For example, some children may have chosen a more popular item for themselves, some may have chosen a more unique item for themselves (as a handful of adults did in Experiment 6), and some may have not used demand inferences in their choices for themselves at all. By adulthood, decisions about resource choice based on demand inference are more systematic and consistent. Future work would investigate the factors driving differences in economic demand reasoning across development.

Another intriguing question for future work concerns the amount of evidence that children need to make demand inferences, and how this might change over development. In our studies, children viewed boxes of stickers with empty compartments to indicate missing stickers. The higher demand box always had more missing stickers, but the lower demand boxes also had stickers missing, suggesting that at least a few children selected those stickers. While the older children were able to make a demand inference under these conditions, this may have led to some uncertainty in the younger children about whether the higher demand stickers were indeed in higher demand. A related source of evidence about economic demand was the number of children who had previously selected stickers (which was indicated by the number of empty boxes). For example, in 9-compartment trials, there were eight total stickers missing; thus, children had information about which resource eight children chose. This evidence may have been enough to drive demand inferences in older children, but may not have been sufficient to drive their own choices; children may put less credence in the choices of a small group, or may be sensitive to the possibility that the choices of a smaller group may not accurately reflect the value of the stickers. Future work would manipulate the amount of evidence children are presented with (e.g. 50 empty spaces indicating the choices of 50 children) and examine the impact on demand inference and choice across age.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cognition.2021.104747.

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