

1 **Child Development, In Press.**

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3 **Young children are wishful thinkers: The development of wishful**  
4 **thinking in 3-to 10- year-old children**

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**Abstract**

14 Previously, research on wishful thinking has found that desires bias older

15 children's and adults' predictions during probabilistic reasoning tasks. In

16 the present paper, we explore wishful thinking in children aged 3- to 10-

17 years-old. Do young children learn to be wishful thinkers? Or do they

18 begin with a wishful thinking bias that is gradually overturned during

19 development? Across 5 experiments, we compare low- and middle-income

20 U.S. and Peruvian 3- to 10-year-old children ( $N=682$ ). Children were asked

21 to make predictions during games of chance. Across experiments,

22 preschool aged children from all backgrounds consistently displayed a

23 strong wishful thinking bias. However, the bias declined with age.

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2 **Keywords:** optimism bias, wishful thinking, probabilistic reasoning,

3 cross-cultural, cross-socioeconomic

1     **Young children are wishful thinkers: The development of wishful**  
2                           **thinking in 3-to 10- year-old children**

3  
4     **Introduction**

5           Previously, psychologists have found that both adults and young  
6 children frequently hold optimistic beliefs. However, the underlying cause of  
7 this optimism is less clear. Some researchers have argued, more specifically,  
8 for a ‘wishful thinking bias’, also called a ‘desirability bias’. According to this  
9 hypothesis, a desire or preference for a specific outcome directly increases  
10 the belief that the desirable outcome will occur. While several studies have  
11 explicitly measured wishful thinking in adults and older children (see Krizan  
12 & Windschitl, 2007; 2009 for review), finding some support for this  
13 hypothesis, previous studies have not explicitly measured wishful thinking in  
14 young children. In the present paper, we explore wishful thinking in young  
15 children, aged 3 to 10, from Peru and the U.S., to uncover the development  
16 trajectory of wishful thinking.

17  
18     **The Relationship Between Preferences and Expectations**

19           For decades researchers have documented a link between preferences  
20 and expectations, finding that people often hold expectations that are  
21 congruent with their preferences (Granberg & Brent, 1983; Hayes, 1936;  
22 Ogburn, 1934). For example, Granberg and Brent (1983) tallied survey data  
23 across 8 presidential elections and found that 4 out of 5 U.S. adults believed

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1 their preferred presidential candidate would win. While this finding, and  
2 others, suggests that people may have optimistic beliefs, it is not always  
3 clear why people have these beliefs. Wishful thinking, as opposed to  
4 optimism more generally, specifically implies that desires have a causal  
5 influence on beliefs. In the example above, presidential preferences may  
6 have driven people's election predictions - they may have believed the  
7 candidate would win precisely **because** they wanted the candidate to win, a  
8 classic case of wishful thinking. Alternatively, however, the prediction may  
9 have driven the preference; people may have preferred that specific  
10 candidate because they believed that candidate would win (not a case of  
11 wishful thinking). Finally, a third variable could have driven both their  
12 preferences, and their predictions; for example, both predictions and  
13 preferences could be shaped by other people's predictions and preferences,  
14 also called a 'bandwagon' effect' (and not a case of wishful thinking).

15       The unrealistic belief would only count as wishful thinking if it was  
16 directly caused by the desire, so to demonstrate wishful thinking we need to  
17 manipulate desires without otherwise changing beliefs. To explicitly test  
18 wishful thinking, researchers have used games of chance to experimentally  
19 manipulate participants' desires, and then measured the influence of those  
20 desires on participants' predictions about stochastic events.

21       The first 'wishful thinking' study was conducted with 9- to 11-year-old  
22 children. In this study, Marks (1951) introduced children to a deck of cards,  
23 some of which were marked on one side, and told children the percentage of

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1 marked cards in the deck. Across conditions, decks contained different  
2 percentages of marked cards (10, 30, 50, 70, and 90%). Across conditions,  
3 participants were also told they would win (gain condition) or lose (loss  
4 condition) a point if they blindly drew a marked card from the deck. After  
5 this, participants were asked to guess which card they thought they would  
6 select from the deck. Responses varied according to both the probability and  
7 desirability of selecting a marked card. Holding likelihood constant,  
8 participants believed they were more likely to select a marked card in the  
9 gain conditions than in the loss conditions, suggesting that desirability  
10 altered expectations. Children's estimates of drawing their preferred card  
11 was heavily skewed across these different ratios. For example, when the  
12 probability of drawing a desirable marked card was 5 to 5, 90% of children  
13 believed they would draw the desirable card. When the probability of the  
14 desirable outcome was a slim 1 to 9, 47% of children still believed they  
15 would draw the desirable card.

16 Since this time, several variations of this paradigm have been  
17 conducted with adults, but none with younger children. In one of these  
18 studies, Irwin (1953) used a nearly identical paradigm to Marks (1951). Irwin  
19 found that when the marked card was desirable, 61% of participants (across  
20 the various probabilities) stated they would draw a marked card, however  
21 when the marked card was undesirable, only 48% did so, suggesting some  
22 effect of desirability on adults' expectations, albeit a much smaller effect  
23 than Marks found in children. Meta-analyses drawing upon several similar

1 studies yielded comparable findings (Krizan & Windschitl, 2007; 2009).  
2 Contrasting these findings with Marks (1951) implies that a wishful thinking  
3 bias may be stronger for school aged children than it is for adults.

4 This raises questions about the development of wishful thinking.  
5 Perhaps a wishful thinking bias is acquired during early childhood. If this is  
6 so, we might predict that the bias would increase with development.  
7 Alternatively, desires could initially constrain young children's predictions  
8 and children may gradually overcome this bias with age. If so, we should see  
9 a desire bias even in very young children, and it should weaken over the  
10 course of development.

11

## 12 **Developmental Research on Optimism and Positivity**

13 While wishful thinking has not been explicitly measured in young  
14 children, several developmental studies have explored optimism more  
15 generally. Many of these studies have measured young children's beliefs  
16 about trait stability, finding that younger children often exhibit a 'positivity  
17 bias' when they evaluate trait stability over the course of time -- young  
18 children expect negative traits to change for the better but believe that  
19 positive traits will remain stable (Diesendruck & Lindenbaum, 2009; Heyman  
20 & Giles, 2004; Lockhart, Chang, & Story, 2002; Lockhart, Nakashima, Inagaki,  
21 & Keil, 2008). For example, Lockhart et al. (2002) introduced young children  
22 (5-to 6-year-olds), older children (7-to 10-year-olds) and adults to a story in  
23 which characters wanted to change a negative attribute for the better (e.g.

1 become more athletic, or more attractive). Younger children were likely to  
2 believe that these negative attributes would change for the better, while  
3 adults judged them to be more stable over time. Similarly, other studies  
4 have asked children about story characters who wanted to change their  
5 positive attribute into a negative one. For example, Heyman and Giles (2004)  
6 introduced children to a character who was smart but did not want to be  
7 smart. In these types of scenarios, young children tend to state that the  
8 positive trait will persist over time, even when the protagonist wished  
9 otherwise.

10         Similarly, in one study, Boseovski and Lee (2008) introduced children  
11 to a story character who either performed positive or negative actions  
12 towards another character. In this study, children readily extended positive  
13 attributes to the story character after viewing positive actions; however they  
14 were hesitant to make a negative inference after viewing negative actions.  
15 Relatedly, Boseovski (2012) explored children's endorsement of an  
16 informant's testimony, finding that children were more likely to endorse an  
17 informant who stated a person was nice, rather than one who stated they  
18 were mean.

19         While these results suggest that young children often hold positive or  
20 optimistic beliefs, it is not clear if young children's *own* preferences caused  
21 their responses. For example, while some of these studies explicitly stated a  
22 story character's desires (e.g. stated that the story character wanted to  
23 change), and experimentally manipulated positive and negative trait valence

1 (e.g. being nice vs. mean), none have measured if the participants' *own*  
2 *desires* actually aligned with the *story character's desires* or the *trait valence*  
3 (Heyman & Giles, 2004; Lockhart, et al. 2002; Lockhart, et al. 2008). As there  
4 were no explicit manipulations of participants desires or measurement of  
5 their preferences, it would be a stretch to argue that these findings are  
6 evidence for wishful thinking in young children, although they are in line with  
7 this hypothesis. Furthermore, there are several alternative explanations for  
8 children's optimism in these previous studies. These alternative explanations  
9 are discussed in the section below.

10         In contrast to the studies reviewed above, other developmental studies  
11 have taken a first-person perspective, finding that young children often  
12 exhibit over-confidence in their own abilities across a variety of situations.  
13 For example, Parsons and Ruble (1977) found that preschool-aged children  
14 expected to do well on a puzzle task, even after being told they were doing  
15 poorly; however, 6-year-olds updated their expectations in response to  
16 negative feedback. Similarly, Plumert (1995) found that 6-year-olds, but not  
17 8-year-olds, demonstrated over-confidence in their physical abilities, such as  
18 running fast. In another study, Lockhart, Goddu, and Keil (2017) found that  
19 5- to 7-year-olds were more likely to think that they would eventually acquire  
20 complete knowledge than were 8- to 10-year-olds.

21         In these first-person studies, it seems quite plausible that children  
22 preferred the positive outcome (e.g. running fast or acquiring more  
23 knowledge). If so, this preference could have influenced their responses.



1 However, again children's desires were not experimentally manipulated  
2 across conditions, nor were they explicitly measured. In addition, as  
3 Lockhart, et al., (2002) discuss, there are several alternative explanations for  
4 these results. These alternative explanations are outlined in the section  
5 below.

6

### 7 **Alternative Explanations for Young Children's Optimism**

#### 8 **Beliefs about the base rate prevalence of positive attributes.**

9 Experimental evidence suggests developmental differences in children's  
10 prior knowledge about personality traits; younger children believe that  
11 positive traits are more prevalent than older children (Lockhart, et al., 2002).  
12 A strong prior belief in favor of positive attributes may cause inferential  
13 biases, even after viewing evidence to the contrary (Gopnik, Griffiths, &  
14 Lucas, 2015; Seiver, Gopnik, & Goodman, 2013). In this case, it would be  
15 important to explore why children have different beliefs about the base rate  
16 prevalence of traits. Children may believe that positive traits are common  
17 because this belief aligns with their desires (e.g. wishful thinking). However,  
18 a number of other factors could shape the development of these beliefs,  
19 such as evidence from the testimony of adults.

20 **Beliefs about the controllability of traits.** Research also suggests  
21 that younger children believe people have more control over the  
22 development of traits and abilities than do adults (Lockhart, et al., 2002;  
23 Stipek & Mac Iver, 1989). This may cause younger children to believe that

1 people can improve over time if they want to. Again, wishful thinking could  
2 influence children's beliefs about the controllability of traits; young children  
3 may believe that people can control outcomes because they wish it to be so.  
4 However, young children may believe this for other reasons. In particular,  
5 they may encounter first-person or testimony evidence that leads them to  
6 conclude this.

7       **First-person evidence.** Children likely receive different patterns of  
8 evidence in their day to day lives than older children and adults, and this  
9 could shape their beliefs about controllability and malleability. Indeed, young  
10 children's traits and abilities do rapidly change during development, which  
11 may lead children to believe that traits and abilities are quite malleable.  
12 Young children may also believe that adults generally have more positive  
13 traits than children; for example, adults do run much faster and have  
14 acquired a much larger body of knowledge. As a result, children may come  
15 to believe that with age everyone's relative standing will improve.

16       **Testimony evidence.** Adults may also selectively provide younger  
17 children with positive and encouraging feedback and this may cause young  
18 children to develop optimistic beliefs about their own abilities. While  
19 kindergarteners generally rate their future academic attainment higher than  
20 4<sup>th</sup> graders do, Stipek and Daniels (1988) found that kindergarteners who  
21 were given salient positive and negative feedback, similar to the feedback 4<sup>th</sup>  
22 graders generally receive, rated themselves comparably to 4<sup>th</sup> graders. In  
23 another study, Stipek, Roberts and Sanborn (1984) found that 4-year-old

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1 children adjusted their estimates of success in response to adult feedback.  
2 Both of these studies suggest that testimony evidence does shape children's  
3 beliefs about their own abilities. This sort of testimony evidence, rather than  
4 wishful thinking, could have underpinned children's confidence in the  
5 previous studies.

6         At least one study provides more direct support for wishful thinking. In  
7 this study, Stipek, et al. (1984) explored whether 4-year-olds' overconfidence  
8 was impacted by incentivizing success. Children were introduced to a  
9 challenging task. In an incentivized condition, children were told they would  
10 receive a reward for success; children in a control condition were not  
11 rewarded for success. After struggling with the task, children's estimates of  
12 eventual success remained higher when success was incentivized than when  
13 it was not, suggesting that manipulating children's desires (through  
14 manipulating the incentive) altered children's expectancies about the  
15 outcome. However, again, there is at least one good alternative explanation  
16 for this finding; it is possible that through offering an incentive,  
17 experimenters also altered children's motivation, which in turn could have  
18 rationally influenced their actual likelihood of success and corresponding  
19 predictions. In this case, desires would not directly impact children's  
20 expectations, but rather their motivation, which in turn could influence their  
21 expectations - in other words children might recognize that they were more  
22 motivated in the incentivized condition and accurately predict that

1 motivation improves performance. If so, wishful thinking would not be the  
2 cause of children's optimism.

3       There is also research indicating that desires strongly constrain  
4 children's initial beliefs about agency. For example, Gopnik and Slaughter  
5 (1991) found that preschool aged children's recollection of their own past  
6 desires was often biased by a current desire. In another study, Moore,  
7 Jarrold, Russell, Lumb, Sapp and MacCallum, (1995) asked children to infer  
8 another person's desire when it was in conflict with their own desire, and  
9 experimentally varied the magnitude of participants' desires. They found  
10 that only 5-year-olds could accurately predict another person's desire when  
11 there was a strong conflict of desire; 3- and 4-year-olds could not. However,  
12 when there was not a strong conflict of desire, even 3-year-olds could make  
13 accurate judgments. These studies differ from studies on wishful thinking  
14 because they ask children to predict desires, rather than future outcomes  
15 that are relevant to participants. However, results could indicate that desires  
16 more broadly constrain young children's inferences.

17       Taken together, research supports the notion that young children  
18 frequently hold optimistic beliefs, particularly about traits and abilities.  
19 Research also suggests that desires bias young children's ability to  
20 accurately predict other desires. However, it is not yet clear if young children  
21 engage in wishful thinking, and if desires bias children's predictions about  
22 outcomes.

1 Previous studies have, however, explicitly measured wishful thinking in  
2 school aged children and adults, generally finding a bias when asking  
3 participants to make binary predictions about stochastic events. These  
4 findings suggest that the bias may attenuate with age. No previous studies  
5 have directly tested wishful thinking in young children, and in particular,  
6 none have measured if desires influence young children's predictions about  
7 stochastic events. In the present paper, experimenters use games of chance  
8 to directly manipulate young children's desires and measure the influence of  
9 desirability on probability judgments.

10

### 11 **Probability Judgments in Early Childhood**

12 One reason that a Marks (1951) wishful thinking style of paradigm has  
13 not been extended to young children sooner is because of the earlier  
14 consensus that young children have difficulty understanding probability. In  
15 the first of these studies, Piaget and Inhelder (1975) introduced 5- to 12-  
16 year-old children to a container holding two colors of chips. The proportion of  
17 each color varied. Children were asked to point to the color of chip they  
18 believed would be randomly selected. Children under the age of seven did  
19 not provide accurate predictions.

20 Other studies have challenged this position, showing that under certain  
21 conditions young children do demonstrate a basic understanding of  
22 probability (Denison & Xu, 2014; Yost, Siegel, & Andrews, 1962). For  
23 example, Yost, et al. (1962) informed five-year-old children that they would

1 receive a prize if they randomly selected a specific color of chip from a  
2 container. Then children were shown two containers, one with a higher  
3 proportion of desirable chips than the other. Children were asked to point to  
4 the container they wanted to take a chip from. Children tended to point to  
5 the container with the higher proportion of desirable chips. In this study,  
6 experimenters also administered a variation of Piaget and Inhelder's (1975)  
7 task and found again that children did not make accurate probability  
8 judgments. However, they also found that if children completed the above  
9 described task prior to the Piagetian task, they reliably made accurate  
10 predictions on the Piagetian task.

11         Given the mixed results in these previous studies, the present  
12 experiments include baseline control conditions that explore three-to seven-  
13 7-olds' ability to make accurate and explicit verbal probability judgments  
14 after viewing a distribution. These control conditions are similar to the classic  
15 Piagetian task but were designed to be simpler and more straightforward for  
16 children.

17

## 18 **Introduction to Experiments 1 to 5**

19         This paper reports findings from five experiments exploring the effects  
20 of desirability and probability on 3- to 10-year-old children's predictions. We  
21 included children from Peru as well as the U.S. We also included lower  
22 income as well as middle income U.S. preschool children. Recently,  
23 psychologists have become conscious of the limitations of only sampling

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1 from W.E.I.R.D. (western, educated, industrialized, rich and democratic)  
2 demographics. For example, a survey of published literature found that less  
3 than 7% of published developmental psychology studies sampled children  
4 from Africa, Central and South America, Asia, Israel and the Middle East,  
5 while less than 1% sampled children from South or Central America (Nielsen,  
6 Haun, Kärtner, & Legare, 2017). This general lack of diversity makes it  
7 difficult to build a comprehensive picture of how development unfolds  
8 universally. Moreover, it seems plausible that cultural and SES differences  
9 might affect the development of wishful thinking and optimism more  
10 generally, though specific comparisons and predictions are not clear given  
11 the paucity of evidence. This gap can only be addressed by actually  
12 conducting studies in a wider range of cultures and socio-economic settings  
13 and using these findings to generate theoretical predictions; this is our  
14 strategy in the present research.

15 In Experiment 1, children viewed a card deck composed of two types of  
16 cards. In Experiments 2, 3, 4, and 5 children viewed a bag of plastic eggs  
17 composed of two colors. Children were asked to guess what card type or egg  
18 color had been randomly selected. The distribution was heavily skewed so  
19 that 80% of objects were of one type, and only 20% were of the other.  
20 Baseline control conditions measured children's probability judgments. In  
21 experimental conditions, the improbable outcome was also desirable. If  
22 young children can make accurate probability judgments, they should  
23 reliably predict the more likely outcome in the control conditions. If

1 desirability alters expectancies, children should predict the unlikely (but  
2 desirable) outcome more often in the experimental conditions than in the  
3 control conditions.

4

5

## Experiment 1 Methods

### 6 **Participants**

7         In the U.S., participants were recruited and tested at children’s science  
8 museums in the San Francisco Bay Area. The sample was predominantly  
9 middle- and upper-middle class, primarily composed of Asian (35%),  
10 Caucasian (33%), and Hispanic or Latino (17%) children. In Peru, children  
11 were recruited and tested in Innova schools located in and around Lima,  
12 Peru. This is a chain of private schools designed to serve largely lower-  
13 middle class children in Peru. Children were primarily second or third  
14 generation internal immigrants from the Peruvian highlands. Children were  
15 from an emerging middle-class background- families who have traditionally  
16 been in the lower class but recently have accumulated some expendable  
17 income. All schools were located in low-income, and largely high-crime  
18 neighborhoods.

19         Two-hundred-and sixty children participated in Experiment 1. The  
20 experimental condition included 41 U.S. 4-year-olds, 41 U.S. 6-year-olds, 23  
21 Peruvian 4-year-olds and 25 Peruvian 6-year-olds. The control condition  
22 included 41 U.S. 4-year-olds, 41 U.S. 6-year-olds, 23 Peruvian 4-year-olds,  
23 and 25 Peruvian 6-year-olds. See Table 1 for mean ages and age ranges. In



1 addition, one child was dropped because of parental interference and two  
2 because of experimenter error.

3

#### 4 **Stimuli and Protocol**

5 Experimenters used white index cards with shapes pictured on one  
6 side. The cards featured black squares and circles (U.S.) or triangles and  
7 circles (Peru). This study was developed in the U.S. then extended to children  
8 in Peru. During the initial piloting in Peru, several of the younger children  
9 called the square a triangle, so experimenters replaced the square shape  
10 with a triangle shape. The experimenters also used small bins filled with  
11 colored plastic containers. The containers held prizes. U.S. participants were  
12 tested in English, and Peruvian participants in Spanish. Study protocols were  
13 translated and back-translated by bilingual research personnel.

14

#### 15 **Procedure**

16 In the U.S., children were tested in a quiet corner of the museum. In  
17 Peru, children were tested in private office spaces in their schools. First, the  
18 experimenter asked children if they liked prizes. Upon affirmation, the  
19 experimenter told children they could win prizes. Children were instructed to  
20 select one container from a bin and were told that it had a prize inside.  
21 Before the child could open the container, the experimenter placed it to the  
22 side of the table, explaining that the child might be able to win the prize  
23 later.

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1           The experimenter next introduced participants to a deck of 20 cards  
2 and told them that the cards had circles and squares (U.S.A.) or circles and  
3 triangles (Peru) on them. The experimenter explained that they were going  
4 to mix the cards up, then randomly select one card from the deck.

5           Next, the experimenter explained the prize contingencies, which  
6 differed across conditions. In the *control* condition, participants were told  
7 that they would win an additional prize, regardless of the experimenter's  
8 card selection from the deck. In the *experimental* condition, participants  
9 were told that they would only win an additional prize if one of the types of  
10 cards (i.e., the unlikely card) was selected, and would lose their initial prize if  
11 the other type was selected. Thus, in the control condition, the children  
12 believed they would receive two prizes regardless of the experimenter's  
13 selection, while in the experimental condition they believed they would  
14 receive two prizes if the experimenter selected the unlikely card, and no  
15 prizes if the experimenter selected the likely card.

16           In the experimental condition, children were asked to state which of  
17 the card types they wanted. If they said they wanted the card that resulted  
18 in no prizes, the experimenter explained the prize contingencies again, and  
19 asked the question again. All but one child agreed they wanted the  
20 experimenter to select the desirable card.

21           Next, the experimenter sorted all cards face up by shape type. Then,  
22 the experimenter and participants counted the number of cards of each  
23 shape. Card decks contained 16 cards of the majority shape, and 4 cards of

1 the minority shape. In the experimental condition, the majority card was  
2 associated with loss, while the minority card was associated with gain.

3 Following this, the experimenter turned the cards over, mixed them up,  
4 selected one card randomly from the deck, and placed it face down on the  
5 table. Children were asked to guess which card the experimenter had  
6 selected (e.g., “What card do you think this is?”). A memory check was  
7 introduced part way through data collection. After making a prediction, 219  
8 children were also asked to state the majority card (e.g., “Do you remember  
9 which card there was more of?”). Majority card type was counterbalanced.

10

## 11 **Experiment 1 Results**

12 Children were scored on whether they stated that the majority card  
13 type had been selected. A binary logistic regression explored if children  
14 predicted the majority card type using condition, country, and age group  
15 (categorical: 4 vs. 6) as predictor variables. The resulting model was  
16 statistically significant,  $\chi^2(3) = 33.129$ ,  $p < .0001$ , Nagelkerke  $R^2 = .163$ ;  
17 there was a main effect of condition,  $\chi^2 = 23.127$ ,  $df = 1$ ,  $p < .0001$ , and age,  
18  $\chi^2 = 8.266$ ,  $df = 1$ ,  $p = .004$ , but not of country,  $p = .355$ , *ns*. Overall, children  
19 were more likely to choose the majority card type in the control condition  
20 than they were in the experimental condition, and older children chose the  
21 majority card type more often than younger children (see Figure 1).

22 Next, we were curious if developmental differences were specific to  
23 either the control or experimental condition. To explore this, we split the

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1 participants by condition, and used two binary logistic regressions to explore  
2 if age impacted predictions. For the control condition, the model was  
3 significant,  $\chi^2(1) = 7.875$ ,  $p = .005$ , Nagelkerke  $R^2 = .088$ ; and age was a  
4 significant predictor variable,  $\chi^2 = 7.266$ ,  $df = 1$ ,  $p = .007$ . Age, however, did  
5 not impact performance in the experimental condition, the model was not  
6 significant,  $\chi^2(1) = 2.013$ ,  $p = .156$ , Nagelkerke  $R^2 = .021$ ; and age was not a  
7 significant predictor variable,  $\chi^2 = 1.997$ ,  $df = 1$ ,  $p < .158$ . In sum, with age,  
8 children provided more accurate responses in the control condition, however,  
9 4- and 6-year-olds were equally likely to engage in wishful thinking in the  
10 experimental condition.

11 In the control condition, children reliably predicted the majority card  
12 type; 99 of 130 children (or 76%;  $SD = .43$ ; 95%  $CI = .69-.84$ ) predicted the  
13 majority card type, which is significantly greater than chance,  $p < .0001$ , two-  
14 tailed binomial test. This was also true when both the 4- and 6-year-old age  
15 groups were considered separately (4-year-olds: 42 of 64, or 66%;  $SD = .48$ ,  
16 95%  $CI = .54-.78$ ;  $p = .017$ , two-tailed; 6-year-olds: 57 of 66, or 86%;  $SD = .35$ ,  
17 95%  $CI = .78-.95$ ;  $p < .0001$ , two-tailed). In the experimental condition, 61 of  
18 130 children (or 47%;  $SD = .5$ ; 95%  $CI = .38-.56$ ) chose the majority card,  
19 which is not significantly different from chance,  $p = .539$ , *ns*. A power analysis  
20 was conducted using the program G\*power, and the means presented  
21 above. Results suggest a total sample size of 90 to find the main effect of  
22 condition (with power  $1 - \beta$  set to .80;  $\alpha = .05$ ; two-tailed test), indicating that  
23 the sample size in the current study was more than adequate.

1 < Insert Figure 1 >

2       Two-hundred-and nineteen children were asked if they remembered  
3 which card there was more of, as well as which card there was less of. In the  
4 *control* condition, 83% of children answered both questions correctly. In the  
5 *experimental* condition, 89% of children correctly answered both questions  
6 (chance is 25%). Looking only at children who responded correctly to the  
7 memory checks, in the control condition 62 of 90 children guessed the  
8 majority, and in the experimental condition 43 of 98 did so. A Fisher's exact  
9 test confirms that the difference between conditions remained significant,  
10  $p=.0007$ . Children's optimism in the experimental condition cannot be  
11 explained by a failure to remember the distribution.

12       Audible video recordings were obtained for 72 children in the control  
13 condition, and 85 in the experimental condition. Using these recordings,  
14 children were retroactively scored on whether they correctly stated the prize  
15 contingencies associated with each of the cards without prompting, and  
16 without any reexplanation from the experimenter. Eighty-three percent (or  
17 60 of 72) of the children in the control condition correctly stated that both  
18 cards would result in two prizes, while 65% (or 55 of 85) of children  
19 accurately recalled the prize contingencies in the experimental condition.  
20 Looking only at these children, 75% (or 45 of 60) stated the majority card in  
21 the control condition, while 55% (or 30 of 55) did so in the experimental  
22 condition. A Fisher's exact test reveals that the difference between  
23 conditions remained significant,  $p=.031$  (two-tailed).

## 1 **Experiment 1 Discussion**

2 Study 1 suggests that 4- and 6-year-old children's verbal predictions  
3 were influenced by both desirability and probability. Children scored  
4 significantly above chance in the control condition, and there was a  
5 significant difference between control and experimental conditions,  
6 indicating an effect of wishful thinking on children's judgments.

7 Older children overall were more likely to state the majority card than  
8 younger children in the control condition, however there was no effect of age  
9 in the experimental condition. This indicates that both 4-and 6-year-olds  
10 were equally likely to engage in wishful thinking, even though 6-year-olds  
11 displayed more advanced probabilistic reasoning skills. Four-year-olds did  
12 score above chance in the control condition, however, their performance was  
13 still not impressive.

14 One concern is that children scored at chance in the experimental  
15 condition. It is possible that desirability biased children's answers, resulting  
16 in a pattern of responses that was meaningfully different from the control  
17 condition, but coincidentally at chance. Alternatively, it is possible that  
18 tracking the two levels of prize contingencies (0 vs. 2 prizes), as well as both  
19 gain and loss contingencies was difficult for children, and children resorted to  
20 guessing.

21 This raises questions about whether the experimental design was  
22 suitable for young children. For example, gathering and shuffling the cards  
23 took a while, and there was a substantial gap in time between when children

1 viewed the distribution, and when the card was selected. The memory  
2 checks at the beginning of the experiment were lengthy, and many children  
3 seemed to lose interest during these. Given this, it is possible that the  
4 developmental trends were caused, at least in part, by developmental  
5 differences in working memory, or attentional regulation. There was also no  
6 reward for correct answers in the control; this may have influenced younger  
7 children's responses.

8         In Experiment 2, we attempted to control for these possibilities and  
9 explore whether we could replicate the previous experiment using different  
10 materials and procedure. First, we used a shorter, more visually simple  
11 version of this task. The experimenter chose a random sample from a  
12 collection of objects which visibly included more of one type than another  
13 (an "urn" type of probability task). Both infants, implicitly, and older  
14 preschool children, explicitly, have demonstrated that they understand  
15 probability in "urn" tasks and assume random sampling (Xu & Garcia, 2008:  
16 Denison & Xu, 2014; Denison, Bonawitz, Gopnik & Griffiths, 2013). We also  
17 included an additional control condition, where children were incentivized for  
18 providing a correct answer, to explore the possibility that greater motivation  
19 might improve the younger children's performance on the control task. In  
20 addition, this new control condition required children to track 3 colors of  
21 eggs that contained 2 different amounts of prizes (0 or 2), matching the  
22 cognitive demands of the experimental condition.

## 1 **Experiment 2 Methods**

### 2 **Participants**

3           One-hundred-and twenty-one North American and 128 Peruvian 3- to  
4 6-year-olds participated. Children were divided across 3 conditions: the  
5 experimental condition, the motivated control condition, and the  
6 unmotivated control condition. See Table 1 for further information on subject  
7 numbers and age. Additionally, 3 participants were tested and not included:  
8 1 child voluntarily withdrew, 1 child failed to provide a response, and 1 was  
9 dropped due to experimenter error.

10

### 11 **Stimuli**

12           In Peru, the experimenter used a special blue plastic egg (motivated  
13 control condition only), a white cloth, a brown paper bag, and a clear plastic  
14 bag containing 10 yellow and purple plastic eggs. Some eggs contained  
15 stickers. In the U.S., stimuli were similar, but egg colors differed. The  
16 experimenter used a silver plastic egg (motivated control condition only),  
17 and a clear plastic bag containing 10 yellow and blue eggs. Experiment 2  
18 was initially developed and tested in Lima, Peru, where experimenters had  
19 limited access to study stimuli. U.S. experimenters changed the egg color  
20 from purple to blue because it was thought that some children (mostly girls)  
21 might have a strong preference for purple eggs, and this might impact the  
22 results. The special blue egg (motivated control condition) was painted silver  
23 in the U.S. to differentiate it from the other eggs.

24



1 **Procedure**

2       **Experimental Condition:** Children were first introduced to a clear  
3 bag containing purple and yellow (Peru) or blue and yellow (U.S.) plastic  
4 eggs. The color distribution was 8 to 2, and the majority color was  
5 counterbalanced. To ensure that children took note of the different colors  
6 and could differentiate them, children were asked to point to one of each  
7 color of egg. Then, the experimenter told participants that the minority egg  
8 color contained 2 stickers and the majority color did not have any stickers.  
9 Following this, the experimenter took 1 of each type of egg out of the bag,  
10 opened them up, and showed the children what was inside. The example  
11 eggs were then reassembled and placed back inside of the plastic bag. Next,  
12 the experimenter asked participants to point to an egg containing 2 stickers  
13 and an egg containing no stickers. The experimenter and child counted out  
14 loud the number of each type. Then the experimenter again asked the child  
15 if they remembered which egg had 2 stickers, and which egg had no stickers.  
16 Next the experimenter held the clear plastic bag of eggs over a brown paper  
17 bag and explained that they were going to place the clear bag into the paper  
18 bag and select 1 egg without looking into the bag, and the child would have  
19 to guess the color. The experimenter also told participants that if the egg  
20 had prizes inside, the child could keep them.

21       Then, the experimenter lowered the clear bag into the opaque bag,  
22 reached in and placed a white cloth over a randomly selected egg. The  
23 selected egg was immediately placed on the table, still under the cloth and

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1 covered by the experimenter's hands. The experimenter said, "Hmm, I  
2 wonder what color it is. What color do you think it is? Purple or yellow?" The  
3 order in which the 2 colors were listed was counterbalanced.

4 **Unmotivated Control Condition:** This condition was identical to the  
5 experimental condition, except that all the eggs contained 2 stickers.

6 **Motivated control condition:** First, the experimenter showed  
7 participants a special blue egg (Peru) or silver egg (U.S.), explaining that it  
8 contained 2 stickers, which could be won. They then opened the special egg  
9 to show that it actually contained 2 stickers.

10 The rest of the procedure was similar to the other conditions, except  
11 for 2 differences. First, there were no stickers inside any of the other eggs  
12 (i.e., the eggs in the clear plastic bag that formed the distribution from which  
13 the experimenter was sampling). Second, children were told that they would  
14 win the stickers inside the special egg if they correctly guessed what color  
15 the experimenter selected from the bag. This is different from the  
16 experimental and unmotivated control conditions, in which children were told  
17 that they would win whatever was inside of the egg *selected* from the bag.  
18 This condition was included to test whether children who were motivated to  
19 be accurate in their predictions would perform better than children who were  
20 not. It also better matched the cognitive demands of the experimental  
21 condition, in that children had to track 2 amounts of prizes (0 vs. 2 stickers)  
22 across 3 colors of eggs, rather than just 1 type of prize contingency (2  
23 stickers) across 2 colors of eggs.

1           In all 3 conditions, after children guessed what color of egg was under  
2 the cloth, they were asked to recall the egg color there was “more of.” In the  
3 experimental condition, they were also asked to recall which egg color they  
4 wanted. We included this question *after* the child’s guess in Experiment 2—  
5 as opposed to *before* the child’s guess in Experiment 1—to control for the  
6 possibility that stating a preference might have primed participants’  
7 guesses. At the end of the procedure, the experimenter revealed the egg  
8 color. All children were immediately given prizes, regardless of the outcome—  
9 either the prizes inside of the egg, or a reward for playing the game.

## 10 **Experiment 2 Results**

11           Children were scored on whether they guessed that the majority egg  
12 color had been drawn from the bag. First a binary logistic regression was  
13 used to compare the experimental to the unmotivated control condition,  
14 using country, exact age (as a continuous variable, given that the children’s  
15 ages ranged from 3 to 6), and condition as predictor variables. The resulting  
16 model was statistically significant,  $\chi^2(3) = 46.133$ ,  $p < .0001$ , Nagelkerke  $R^2$   
17 = .329. Analyses revealed a main effect of condition,  $\chi^2 = 32.971$ ,  $df = 1$ ,  $p$   
18  $<.0001$ , and age,  $\chi^2 = 7.43$ ,  $df = 1$ ,  $p = .006$ , but not country,  $p=.419$ , *ns*. As  
19 in Experiment 1, children chose the majority egg more often in the  
20 unmotivated control condition than in the experimental condition, and older  
21 children chose the majority egg color more often than younger children.

22           A second binary logistic regression compared the motivated control  
23 condition to the experimental condition. Country, exact age (as a continuous

1 variable), and condition were entered into the model as predictor variables.  
2 The resulting model was also statistically significant,  $\chi^2(3) = 39.927$ ,  $p$   
3  $< .0001$ , Nagelkerke  $R^2 = .283$ . Analyses again revealed a main effect of  
4 condition,  $\chi^2 = 32.71$ ,  $df = 1$ ,  $p < .0001$ . Age trended towards being a  
5 significant predictor,  $\chi^2 = 3.151$ ,  $df = 1$ ,  $p = .076$ . Country was not  
6 significant,  $p = .444$ , *ns*. Children chose the majority egg more often in the  
7 motivated control condition than in the experimental condition, and older  
8 children trended towards choosing the majority egg color more often than  
9 younger children. As in Experiment 1, children demonstrated a wishful  
10 thinking bias.

11       Next, we split data by condition, and used three binary logistic  
12 regressions to explore if age influenced responses within each condition  
13 individually. In the experimental condition, age did not predict children's  
14 performance. The model was not significant,  $\chi^2(1) = 2.527$ ,  $p = .112$ ,  
15 Nagelkerke  $R^2 = .046$ , and age was not a significant predictor,  $\chi^2 = 2.456$ ,  $df$   
16  $= 1$ ,  $p = .117$ . Age, however, did impact children's performance in the  
17 unmotivated control condition. The model was significant,  $\chi^2(1) = 5.132$ ,  $p$   
18  $= .023$ , Nagelkerke  $R^2 = .087$ , and age was a significant predictor variable,  $\chi^2$   
19  $= 4.664$ ,  $df = 1$ ,  $p = .031$ . In the motivated control condition, the model was  
20 again not significant,  $\chi^2(1) = .806$ ,  $p = .369$ , Nagelkerke  $R^2 = .013$ , and age  
21 was not a significant predictor variable,  $\chi^2 = .79$ ,  $df = 1$ ,  $p = .374$ . In sum,  
22 with age, children provided more accurate responses in the unmotivated

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1 control condition, however age did not impact responses in either the  
2 experimental or motivated control conditions.

3 Two-tailed binomial tests confirmed that children chose the majority  
4 option significantly above chance in the unmotivated control condition (57 of  
5 81, or 70%;  $SD=.46$ ; 95% CI = .6- .81),  $p=.0003$ , as well as in the motivated  
6 control condition (59 of 86, or 67%;  $SD=.47$ ; 95% CI= .59-.79),  $p=.0007$ ;  
7 there were no differences between the two control conditions,  $p=.867$ , *ns*,  
8 two-tailed Fisher's exact test. In contrast, children scored significantly *below*  
9 chance in the experimental condition. Only 19 of 82, or 23% ( $SD= .42$ ; 95%  
10 CI=.14-.33) of children stated the experimenter had selected the majority  
11 egg,  $p<.0001$ . Most children believed that the experimenter had selected  
12 the desirable, yet highly improbable, egg. A power analysis was conducted  
13 using the software G\*power, and the means presented above. Results  
14 suggest a total sample size of 37 to find the difference between the  
15 experimental and unmotivated control conditions, and a total sample size of  
16 39 to find the difference between the experimental and motivated control  
17 conditions (with power  $1- \beta$  set to .80;  $\alpha = .05$ ; two-tailed test). Again, this  
18 suggests that the sample size used in the current study was more than  
19 adequate and validates the sample sizes used in the following experiments,  
20 which enlist a similar paradigm.

21 In the experimental condition 83% of participants stated they wanted  
22 the egg with the prizes, and 76% correctly stated which egg there was more  
23 of. In the motivated control condition, 85% correctly stated the majority egg

1 color, and 91% did so in the unmotivated control condition. Looking only at  
2 children who passed the memory check questions, and also stated they  
3 wanted the egg with the prizes, in the unmotivated control 50 of 74 (68%)  
4 children predicted the majority egg, in the motivated control condition 48 of  
5 72 (67%) guessed the majority egg, and in the experimental condition 11 of  
6 52 (21%) predicted the majority egg. Fisher's exact tests confirm that the  
7 difference between the unmotivated control and experimental conditions  
8 remained significant,  $p < .0001$ , as did the difference between the motivated  
9 control and experimental conditions,  $p < .0001$ .

10

## 11 **Experiment 2 Discussion**

12 Like Experiment 1, Experiment 2 indicated a difference between the  
13 experimental and control conditions, supporting the hypothesis that young  
14 children engage in wishful thinking. In the experimental condition, very few  
15 children, only 23%, predicted the likely outcome, which was significantly  
16 below chance. Age did not impact children's responses in the experimental  
17 condition.

18 In control conditions, children again made accurate probability  
19 judgments, scoring above chance on both control conditions. Children's  
20 performance in the unmotivated control condition was generally similar to  
21 their performance in Experiment 1, where children's accuracy increased with  
22 age. Performance in the motivated control condition, however, did not show  
23 an age effect. This suggests that the age differences in control conditions

1 might reflect motivational differences. Children’s mean scores, however,  
2 were similar across all control conditions.

3       In the experimental condition in Experiment 2, most children (77%)  
4 stated the unlikely (and desirable) outcome, whereas in Experiment 1, only  
5 53% did so. This may be because the design in Experiment 2 was simpler  
6 and more straightforward for children, decreasing the noise in children’s  
7 responses. A few changes in particular may have made the experimental  
8 condition easier for young children to follow. First, prizes were inside of the  
9 eggs, rather than contingently given to children from an external source.  
10 Second, in Experiment 2, the eggs simply had 2 prizes or no prizes. In  
11 Experiment 1 children were given an initial prize, then, based on the  
12 experimenter’s selection they were either given 1 more prize, or the initial  
13 prize was taken away. This may have been confusing. Additionally,  
14 Experiment 2 was faster, and more visually appealing, possibly making it  
15 easier for children to track the information.

16

### 17 **Experiment 3**

18       In Experiment 3, we extend this paradigm to 3- to 5-year-old children  
19 enrolled in Head Start programs in Berkeley, California. To be eligible for  
20 enrollment in Head Start, families’ income must fall below the federal  
21 poverty level, which, at the time of testing, was below \$24,600 for a family of  
22 4 (“2017 Poverty Guidelines,” 2017). Economists of happiness have reported  
23 that levels of optimism, happiness, and life satisfaction vary by income, with

1 people from lower SES backgrounds consistently scoring lower on these  
2 measures than those from middle- and upper- middle class backgrounds  
3 (e.g. Graham; 2017; Kahneman & Deaton, 2010). This could indicate that  
4 lower-SES children may be less prone to a wishful thinking bias (as it is a  
5 type of optimism). However, Marks (1951) found that SES did not impact  
6 wishful thinking in grade school children, suggesting that the lower-SES U.S.  
7 children might score similarly to the samples previously tested.

8

### 9 **Experiment 3 Methods**

#### 10 **Participants**

11 Experiment 3 included 45 children. Twenty children participated in the  
12 experimental condition ( $M$  age= 4.47,  $DS$ = .59;  $range$ = 3.5 to 5.46), and 25  
13 in the control condition ( $M$  age= 4.46,  $SD$ = .6;  $range$ = 3.43 to 5.59). Children  
14 were recruited and tested at Head Start programs in Berkeley, CA.

15

#### 16 **Methods**

17 Methods were identical to the experimental and unmotivated control  
18 conditions of Experiment 2; all children viewed a clear bag of blue and yellow  
19 eggs. Children were tested in a quiet room or hallway at their preschool.

20

#### 21 **Results**

22 Children were scored according to whether they guessed the majority  
23 egg color. A binary logistic regression measured if age (as a continuous



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1 variable) and condition predicted majority response. The model was  
2 statistically significant  $\chi^2(2) = 12.416, p=.002$ , Nagelkerke  $R^2 = .326$ .  
3 Analyses revealed a main effect of condition,  $\chi^2 = 8.339, df = 1, p = .004$ .  
4 There was no effect of age,  $p=.135, ns$ .

5 Two-tailed binomial tests compared responses to chance. In the  
6 experimental condition, only 3 of 20 (or 15%;  $SD = .37$ ; 95%  $CI = -.02 - .32$ )  
7 children guessed the majority egg, which is significantly below chance,  
8  $p=.003$ ; in the control condition 15 of 25 (or 60%;  $SD = .5$ ; 95%  $CI = .39 - .81$ )  
9 children guessed the majority egg, which is not significantly different from  
10 chance,  $p=.424, ns$ .

11 In the experimental condition, all but 1 child (95%) stated they wanted  
12 the desirable egg. In the control condition, 68% of children correctly stated  
13 the majority egg color, while 60% of children did so in the experimental  
14 condition. Looking only at these children, 9 of 17 (53%) children stated the  
15 majority color in the control condition, and only 1 of 11 (9%) did so in the  
16 experimental condition. The difference across conditions remained  
17 significant,  $p=.041$  (two-tailed Fisher's exact test).

18

### 19 **Experiment 3 Discussion**

20 Experiment 3 extends findings from Experiments 1 and 2 to lower  
21 income children in the U.S.A. Three-to 5-year-old children enrolled in Head  
22 Start programs displayed very high levels of wishful thinking, where 85% of  
23 children provided an optimistically biased response in the experimental

1 condition. These responses are similar to the middle-income U.S. American,  
2 and Peruvian 3- to 5- year-olds.

3

#### 4 **Experiment 4**

5 Age did not influence 4-to- 6-year-olds' responses in the experimental  
6 conditions of Experiments 1, 2 and 3. Children displayed high levels of  
7 wishful thinking across experiments; for example, 77% of children stated  
8 that the highly improbable, yet desirable egg was selected in Experiment 2.  
9 Intuitively, it seems that adults would not show such a strong bias, and that  
10 with age, this bias should attenuate, at least to some extent. We explore this  
11 more in Experiments 4 and 5 by extending this paradigm to older children.

12

#### 13 **Experiment 4 Methods**

##### 14 **Participants**

15 Eighty U.S. and 80 Peruvian 5- to 7-year-olds participated in this study.  
16 Participant demographic information and testing setup were similar to that of  
17 Experiments 1 and 2. See Table 1 for more information on subject ages.  
18 Additionally, one 6-year-old was tested and not included in the final sample  
19 due to experimenter error.

20

##### 21 **Methods**

22 Procedures were identical to the experimental and unmotivated control  
23 conditions of Experiments 2 and 3 with two exceptions. First, children were

1 not told there were stickers inside of the eggs or shown the prizes. Rather,  
2 they were told that the eggs contained “prizes.” This was to control for any  
3 developmental differences in the desirability of specific types of prizes.  
4 Second, light blue and yellow eggs were used for children from both Peru  
5 and the U.S.

6

## 7 **Results**

8 A binary logistic regression explored if children’s responses were  
9 predicted by age (continuous) country (Peru vs. U.S.A.) and condition  
10 (experimental vs. control). The model was significant,  $\chi^2(3) = 38.456$ ,  $p$   
11  $<.0001$ , Nagelkerke  $R^2 = .286$ . Analyses revealed a main effect of condition,  
12  $\chi^2 = 29.984$ ,  $df = 1$ ,  $p <.0001$ , indicating that children were more likely to  
13 guess the majority egg color in the control condition than in the  
14 experimental condition. There was a trending effect of age,  $\chi^2 = 2.98$ ,  $df = 1$ ,  
15  $p = .084$  indicating that older children were slightly more likely to choose the  
16 majority egg color than younger children; country was an insignificant  
17 predictor,  $p = .258$ , *ns*.

18 < Insert Figure 2 >

19 Next, we split participants into condition, and two binary logistic  
20 regressions were used to explore if age (as a continuous variable) predicted  
21 children’s responses in the experimental and control conditions individually.  
22 Age did not predict children’s responses in the control condition, the model  
23 was not significant,  $\chi^2(1) = 1.321$ ,  $p = .25$ , Nagelkerke  $R^2 = .025$ , and age

1 was not a significant predictor,  $\chi^2 = 1.322$ ,  $df = 1$ ,  $p = .25$ , *ns*. Age was,  
2 however, a significant predictor in the experimental condition. The model  
3 was significant,  $\chi^2(1) = 10.227$ ,  $p = .001$ , Nagelkerke  $R^2 = .166$ , and age was  
4 a significant predictor variable  $\chi^2 = 9.202$ ,  $df = 1$ ,  $p = .002$ . This finding  
5 indicates that with age, children were less likely to display wishful thinking.

6 Two-tailed Binomial tests were again used to compare children's  
7 responses to chance. Overall, in the control condition, 63 of 80 (or 79%;  $SD =$   
8  $.41$ , 95%  $CI = .7 - .88$ ) children predicted the majority response, which is  
9 significantly above chance  $p < .0001$ . This can be contrasted with the  
10 experimental condition, where 27 of 80 (or 34%;  $SD = .48$ , 95%  $CI = .23 - .44$ )  
11 children stated the majority response, which is significantly below chance,  
12  $p = .005$ .

13 < Insert Table 1 >

14 At the end of the experiment, 94% of children in the control condition  
15 and 81% of children in the experimental condition correctly recalled the  
16 majority color. In the experimental condition, all but 7 children (91%) stated  
17 they wanted the egg with the prizes. After removing the children who  
18 answered these questions incorrectly, 58 of 75 (or 77%) children in the  
19 control condition and 16 of 61 (or 26%) children in the experimental  
20 condition guessed the majority egg. A Fisher's exact test confirmed that the  
21 difference between conditions remained significant,  $p < .0001$ .

22

## 23 **Experiment 4 Discussion**

1 Experiment 4 again found a strong effect of wishful thinking. Children  
2 were much more likely to state the majority egg color in the control condition  
3 than in the experimental condition. We also saw that age influenced  
4 children's responses in the experimental condition; older children were less  
5 likely than younger children to display a wishful thinking bias. No difference  
6 was observed in the control condition. In sum, Experiment 3 replicates  
7 findings from Experiments 1 and 2, and provides initial support for the  
8 hypothesis that wishful thinking declines with age. In Experiment 5, we  
9 follow up on this finding by testing 7-to 10-year-old children in the U.S.

10

## 11 **Experiment 5 Methods**

### 12 **Participants**

13 Participants included 32 7-to 10-year-old children (mean age= 8.69,  
14 SD=1.04, range= 7.02 to 10.55) from the San Francisco Bay Area.  
15 Additionally, 1 child was tested and dropped because the experimenter did  
16 not obtain a birthdate. Participant demographic information is similar to  
17 Experiments 1 to 4. Due to limitations in access to Peruvian children, data  
18 analysis for Experiment 5 is restricted to the U.S. However, experimenters  
19 were able to collect a partial sample of Peru 7- and 8-year-olds ( $n=16$ ), and  
20 these children are included in Table 1 as well as the meta-analysis after  
21 Experiment 5. Demographic information for these children is similar to that  
22 in the previous experiments.

23

## 1 **Methods**

2           Methods were identical to the experimental condition of Experiment 4.  
3 Given that the previous samples demonstrated proficient probabilistic  
4 reasoning skills, and age is the primary variable of interest, a control  
5 condition was not included.

6

## 7 **Results**

8           A binary logistic regression was used to explore if age (continuous  
9 variable) predicted children's responses in the experimental condition.  
10 Results indicated a significant effect of age. The model was significant,  $\chi^2(1)$   
11 = 12.153,  $p < .001$ , Nagelkerke  $R^2 = .454$ , and age was a significant predictor  
12 variable,  $\chi^2 = 6.747$ ,  $df = 1$ ,  $p = .009$ .

13           Twenty-three of 32 (or 72%;  $SD = .46$ , 95% CI of the mean = .55 to .88)  
14 children stated the majority egg color, which is significantly greater than  
15 chance would predict,  $p = .02$  (two-tailed binomial test), indicating that most  
16 7-to 10-year-old children did *not* demonstrate wishful thinking.

17           At the end of the experiment, 3 children did not correctly state the  
18 majority egg color, and 1 child did not state that they wanted the egg color  
19 with the prizes. Removing these children from the sample indicates that 21  
20 of 28 (or 75%) of children still chose the majority egg color, which is still  
21 significantly above chance,  $p = .013$  (two-tailed binomial test). A regression  
22 analysis on these children revealed age trends comparable to those  
23 described above.

1

## 2 **Experiment 5 Discussion**

3       Experiment 5 extends on findings from Experiment 4 and suggests that  
4 children's tendency to engage in wishful thinking continues to decline  
5 between 7 and 10 years of age. In this study, most children did not display a  
6 bias, however previous studies have found evidence for wishful thinking in  
7 grade school children and even adults. Notably, however, the adult research  
8 suggests that the bias is only reliably observed when the ratio of the two  
9 outcomes is near 50:50. In the present study, the ratio was much more  
10 extreme, 80:20. Given this, it would be interesting to measure 7-to 10- year-  
11 olds' predictions with less extreme ratios.

12       Additionally, previous studies used slightly different methods than the  
13 present study. For example, in the present study, we visually display the  
14 ratios directly to children, whereas Marks (1951) verbally stated the ratios to  
15 children. The present study also asked children to make judgments about an  
16 event that had already occurred (the egg was already selected when  
17 children were asked to make the judgment), whereas Marks (1951) and  
18 others asked participants to make a prediction about a card that would be  
19 selected in the near future. These types of methodological differences could  
20 have influenced participant's tendency to display a wishful thinking bias.

21

## 22 **Meta-Analysis**

1           To further explore the observed age trend on wishful thinking, we  
2 conducted a meta-analysis on the experimental conditions from Experiments  
3 2, 4, and 5. This resulted in a total of 194 children. To get a more complete  
4 picture of developmental trends within each country, we also included 16  
5 Peruvian 7- and 8-year-olds (mean age= 7.8; SD= .31; range= 7.05- 8.27)  
6 who were tested for Experiment 5, however, due to limitations, a complete  
7 sample was not collected. This resulted in a total sample size of 210 children  
8 (mean age= 6.29; SD= 1.6; range= 3.53- 10.55).

9           First, a binary logistic regression explored the effect of age on all  
10 children's responses. The model was significant,  $\chi^2(1) = 37.973$ ,  $p < .0001$ ,  
11 Nagelkerke  $R^2 = .23$ , and age was a significant predictor variable,  $\chi^2 =$   
12  $30.046$ ,  $df = 1$ ,  $p < .0001$ .

13           Next, we split the data set by country. This resulted in 113 U.S.  
14 children (mean age= 6.51; SD= 1.77, range= 3.53- 10.55) and 97 Peruvian  
15 children (mean age= 6.02; SD= 1.33; 3.64- 8.27). Two binary logistic  
16 regressions explored the effect of age on responses. The model for the U.S.  
17 children was highly significant,  $\chi^2(1) = 42.084$ ,  $p < .0001$ , Nagelkerke  $R^2$   
18 = .418, and age was a significant predictor variable,  $\chi^2 = 25.976$ ,  $df = 1$ ,  $p$   
19  $< .0001$ . In Peru, the model did not approach significance,  $\chi^2(1) = 1.12$ ,  
20  $p = .29$ , Nagelkerke  $R^2 = .017$ , and age was not a significant predictor  
21 variable,  $\chi^2 = 1.102$ ,  $df = 1$ ,  $p = .294$ . Additionally, we split participants into  
22 quartiles based on age, then further divided them by country. Table 2  
23 presents an overview of ages and responses.



1 <Insert Table 2>

2

### 3 **General Discussion**

4        Across all experiments, 3- to 5-year-old children reliably displayed a  
5 very strong wishful thinking bias. This finding held across cultures and  
6 socioeconomic backgrounds. In the U.S., this bias gradually declined with  
7 age, with preschool children displaying the strongest bias and 7-to 10-year-  
8 olds displaying no bias. The meta-analysis suggests that this trend may be  
9 different in Peru, possibly weaker, or later developing, however further  
10 research should be conducted with older Peruvian children given that the  
11 age ranges were slightly different across populations.

12        Across experiments, children made accurate probabilistic judgments in  
13 control conditions, with the exception of the lower income children in  
14 Experiment 3. In Experiments 1 and 2, older children made more accurate  
15 judgments in the control conditions than younger children. Even so, the  
16 youngest children still reliably provided accurate responses. These results  
17 confirm the earlier findings on probabilistic reasoning, suggesting that  
18 children's success may be largely dependent on the task demands of the  
19 experimental design. With appropriately simplified materials, children under  
20 7 can give explicit and accurate probabilistic judgments.

21        We found that age influenced children's judgments in the experimental  
22 condition; older children were less likely to display wishful thinking than  
23 younger children. Previously, researchers have measured wishful thinking in

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1 school age children and adults, and those results suggest that wishful  
2 thinking may continue to decline during development. This raises questions  
3 about what specifically changes with age, and why older children and adults  
4 are less likely to engage in wishful thinking than young children.

5         One possibility is that there is simply a strong early, perhaps even  
6 inbuilt, tendency for desires to causally influence predictions and that this  
7 tendency becomes weaker with age. However, these results could also  
8 suggest that young children's beliefs about uncertain outcomes undergo  
9 conceptual revision over development, and these beliefs, rather than a direct  
10 influence of desires on predictions, are responsible for changes in wishful  
11 thinking. Young children may initially use their desires to predict uncertain  
12 outcomes, or even believe that their desires have a causal impact on  
13 outcomes. Indeed, in some cases this may be a reasonable assumption, for  
14 example, in cases where people can actually exert control over outcomes. In  
15 addition, adults often modify outcomes to be consistent with infants and  
16 young children's desires; they help children get what they want, providing  
17 further support for this belief. As children get older, they may encounter  
18 more situations where they don't get what they want and where the link  
19 between desires and outcomes is more tenuous. Over the course of time,  
20 children may begin to realize that desires don't always lead to outcomes,  
21 and instead rely on other information to make predictions, such as the  
22 likelihood evidence in the present studies.

1           Alternatively, people may continue to have a strong disposition  
2 towards wishful thinking throughout development, either intrinsically, or as a  
3 result of beliefs, but their other beliefs about randomness and probability  
4 could undergo conceptual change with development and offset this  
5 tendency. As their understanding of probability improves, children may begin  
6 to override the tendency to engage in wishful thinking. Of course, changes  
7 could also occur along several dimensions simultaneously.

8           These competing hypotheses can all explain why adults and older  
9 children still show some evidence of a wishful thinking bias. Adults and older  
10 children could simply hold a weaker desire bias, or a weaker belief that  
11 desires cause outcomes, resulting in less biased inferences in both cases. If  
12 so, adults and older children should be less likely than younger children to  
13 display wishful thinking across a variety of situations. Alternatively, adults  
14 and older children may develop a stronger belief in the alternative  
15 hypothesis that probability influences the outcome. If so, wishful thinking  
16 might reemerge when evidence in favor of the alternative hypothesis is weak  
17 or nonexistent (e.g. ratios are less extreme, or no probability evidence is  
18 provided), when the causal pathway towards an outcome is more convoluted  
19 and mysterious, or when participants are asked to make judgments in  
20 domains where they have limited prior knowledge.

21           In addition to explaining why wishful thinking changes during  
22 development, these accounts can be used to make predictions about how  
23 wishful thinking relates to childhood optimism more generally. If wishful

1 thinking is generally responsible for optimism and children's wishful thinking  
2 declines, then we should see optimism decline at a similar pace across  
3 domains. Moreover, it should be possible to explore whether there are  
4 correlations between changes in wishful thinking and in other kinds of  
5 optimism. However, if children display less wishful thinking because they  
6 develop a stronger belief in a competing hypothesis, then developmental  
7 changes in optimism that result from wishful thinking should differ across  
8 domains, and should depend on the availability of evidence in favor of the  
9 alternative hypothesis.

10       There are some limitations to the current studies. Earlier studies and  
11 the performance in the control conditions suggest that children do indeed  
12 infer a random sampling process. Moreover, the experimenters in all the  
13 studies emphasized the random nature of the events - shuffling the cards  
14 and mixing up the eggs in an opaque bag, events that even infants interpret  
15 as random processes (e.g. Denison and Xu, 2014), closing their eyes and  
16 looking away while selecting an egg, and explicitly stating that they did not  
17 know the outcome. However, it is possible that children may have thought  
18 that the experimenter intentionally "fixed" the process in a deceptive way to  
19 give them the prizes, analogous perhaps to adults intentionally letting  
20 children win card games. Given this possibility, one next step could be to  
21 explore if the findings replicate in a condition where the random process  
22 does not involve an agent.

1           Another possibility is that children could have stated the desirable  
2 response partly because there was no cost associated with being incorrect.  
3 The motivated control condition in Experiment 2 did suggest that motivating  
4 younger children to be correct increased their accuracy, but no conditions  
5 explored whether associating a cost or benefit with accuracy would alter  
6 children's predictions in the experimental conditions.

7           Another possibility is that reasoning about probability together with  
8 desirability requires advances in some other aspect of cognition, such as  
9 inhibitory control. Perhaps stating the probable outcome in the experimental  
10 condition requires children to first inhibit themselves from stating the  
11 desirable outcome. If so, older children and adults may display a stronger  
12 bias under certain conditions, for example when they are asked to make  
13 rapid judgments.

14           In any case, these studies support the hypothesis that young children,  
15 from all the backgrounds we tested, have a strong wishful thinking bias, and  
16 that wishful thinking declines with age. However, it is not yet clear exactly  
17 why young children engage in wishful thinking and what causes  
18 developmental change. Furthermore, it is not yet entirely clear how wishful  
19 thinking is related to previous developmental findings on optimism,  
20 positivity, confidence and theory of mind. Future research should more  
21 thoroughly explore these questions.

22

1

## **Acknowledgments**

2

3           The authors would like to thank the Bezos Family Foundation and  
4 Carlos Rodríguez-Pastor for funding. They also wish to thank research  
5 assistants Denise Segovia Galván, Karen Ramirez Balarezo and Ingrid Del  
6 Rosario Abanto Hurtado for data collection and Sophie McMullen for help with  
7 coding.

8

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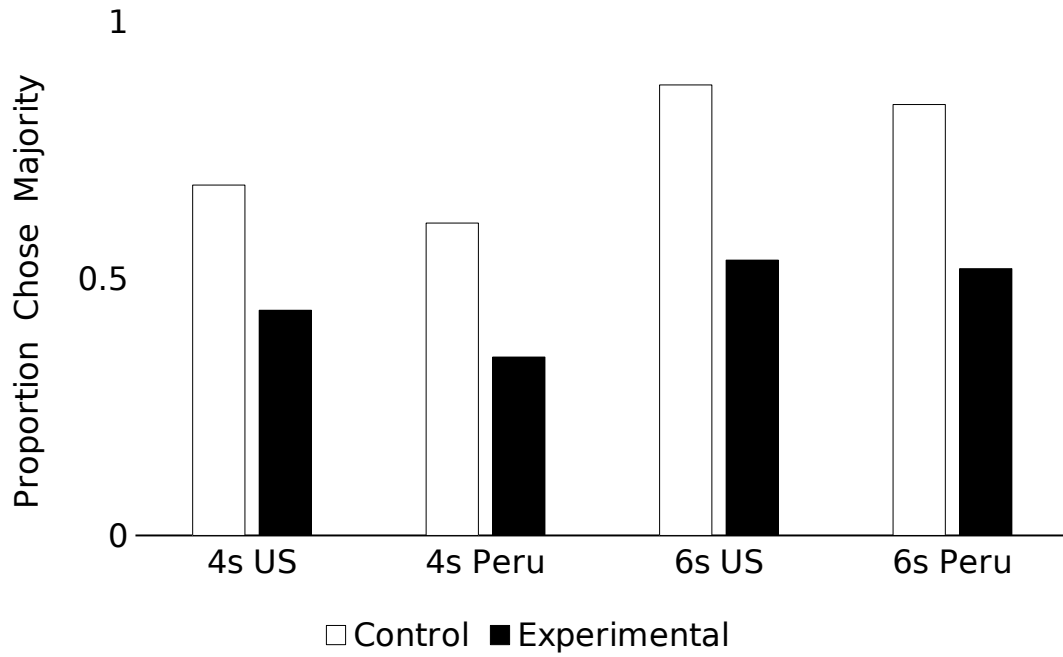
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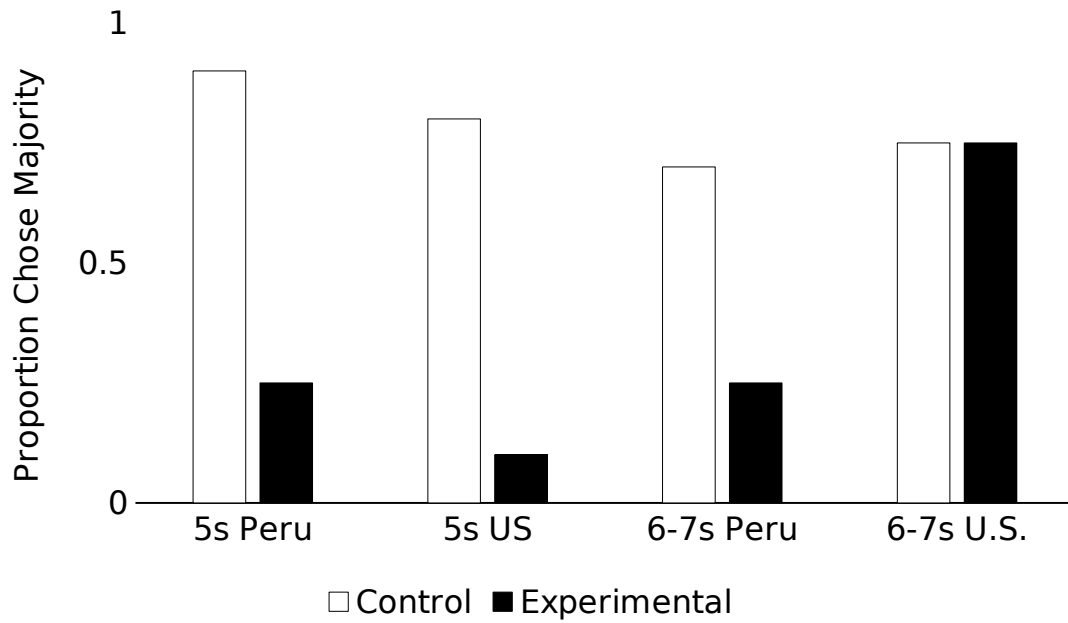
2 **Figure 1.** Proportion of children who stated the majority response in  
3 Experiment 1. Error bars represent one standard error of the mean.

4

5

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2

3 **Figure 2.** Proportion of children who stated the majority response in  
4 Experiment 4. Error bars represent one standard error of the mean.

5

6

1 **Table 1.**

2 Summary of participants ages and responses. Table includes subject  
 3 numbers, mean ages (one standard deviation of the mean age), age ranges,  
 4 the percent (and number) of participants who guessed the majority card or  
 5 egg, 95% confidence intervals for the mean number participants who  
 6 guessed the majority card or egg, and p-values from two-tailed binomial  
 7 tests comparing the pattern of responses to chance.

8  
 9

<b>Group</b>	<b><i>n</i></b>	<b>Mean Age (SD)</b>	<b>Age Range</b>	<b>% (#) Guessed Majority</b>	<b>95% CI for the Mean</b>	<b>Binomial Tests</b>
<b>Experiment 1</b>						
U.S. Experimental 4s	41	4.47 (.3)	3.86-5	44% (18)	.28- .6	$p=.533$
U.S. Experimental 6s	41	6.44 (.31)	5.94-7	54% (22)	.38- .7	$p=.755$
U.S. Control 4s	41	4.47 (.32)	3.9-5.09	68% (28)	.53- .83	$p=.028$
U.S. Control 6s	41	6.47 (.33)	5.95-7	88% (36)	.77- .98	$p<.0001$
Peru Experimental 4s	23	4.54 (.27)	3.97-4.85	35% (8)	.14- .56	$p=.21$
Peru Experimental 6s	25	6.55 (.25)	6.06-7.0	52% (13)	.31- .73	$p=1$
Peru Control 4s	23	4.3 (.32)	3.87-4.98	61% (14)	.39- .82	$p=.405$
Peru Control 6s	25	6.55 (.33)	5.94-6.98	84% (21)	.69- .99	$p<.001$
<b>Experiment 2</b>						
U.S. Experimental	41	5.08 (1.1)	3.53-6.96	20% (8)	.07- .32	$p<.001$
U.S. Unmotivated	40	4.98 (1.05)	3.51-6.99	78% (31)	.64- .91	$p<.001$
U.S. Motivated	40	5.05 (1.04)	3.55-6.95	68% (27)	.52- .83	$p=.039$
Peru Experimental	41	5.13 (1.11)	3.64-7	27% (11)	.13- .41	$p=.004$
Peru Unmotivated	41	5.41 (1.13)	3.7-7.1	63% (26)	.48- .79	$p=.117$
Peru Motivated	46	4.82	3.65-6.83	70%	.56- .83	$p=.011$

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		(.92)		(32)			
<b>Experiment 3</b>							
Low-SES Experimental	20	4.47 (.59)	3.5- 5.46	15% (3)	-.02- .32	$p=.003$	
Low- SES Control	25	4.46 (.59)	3.43- 5.59	60% (15)	.39- .81	$p=.424$	
<b>Experiment 4</b>							
U.S. Experimental	40	6.23 (.89)	4.94- 7.86	43% (17)	.26- .59	$p=.43$	
U.S. Control	40	6.23 (.88)	4.98- 7.84	78% (31)	.64- .91	$p<.001$	
Peru Experimental	40	6.22 (.94)	5.01- 7.94	25% (10)	.11- .39	$p=.002$	
Peru Control	40	6.36 (.88)	5.00- 7.95	80% (32)	.67- .93	$p<.001$	
<b>Experiment 5</b>							
U.S. Experimental	32	8.69 (1.04)	7.02- 10.55	72% (23)	.55- .88	$p=.02$	
<b>Additional Data</b>							
Peru Experimental	16	7.8 (.31)	7.05- 8.27	31% (5)	.06- .57	$p=.21$	

1 **Table 2.**  
2 Summary of participants included in the meta-analysis on experimental  
3 conditions and responses given. Table 2 includes subject numbers, mean  
4 ages (one standard deviation of the mean age), age ranges, the percent (and  
5 number) of participants who stated the majority egg color, 95% confidence  
6 intervals for the mean number of participants who stated the majority egg  
7 color, and p-values from two-tailed binomial tests comparing majority  
8 responses to chance. Data is split into quartiles based on participants' ages,  
9 then further subdivided by country; quartiles are age matched across  
10 countries, with the exception of the eldest quartile.

<b>Group</b>	<b>n</b>	<b>Mean Age (SD)</b>	<b>Age Range</b>	<b>% (#) Guesse d Majority</b>	<b>95% CI for the Mean</b>	<b>Binomi al Tests</b>
<b>Peru and U.S.</b>						
All participants	210	6.29	3.53-	35%	.29- .42	$p<.000$

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Youngest	53	(1.6) 4.35 (.54)	10.55 3.53- 5.11	(74) 17% (9)	.07- .27	1 $p < .000$
2nd youngest	53	5.64 (.31)	5.13- 6.16	21% (11)	.09- .32	1 $p < .000$
2nd oldest	52	6.78 (.38)	6.18- 7.47	37% (19)	.23- .5	$p = .07$
Oldest	52	8.42 (.86)	7.49- 10.55	67% (35)	.54- .8	$p = .018$
<b>U.S.</b>						
All participants	113	6.51 (1.77)	3.53- 10.55	43% (48)	.33- .52	$p = .132$
Youngest	28	4.37 (.58)	3.53- 5.11	11% (3)	-.02- .23	1 $p < .000$
2nd youngest	27	5.74 (.26)	5.29- 6.16	19% (5)	.29- .34	$p = .002$
2nd oldest	26	6.83 (.37)	6.18- 7.47	50% (13)	.29- .71	5 $p = 1.15$
Oldest	32	8.78 (.92)	7.56- 10.55	84% (27)	.71- .98	1 $p = .000$
<b>Peru</b>						
All participants	97	6.02 (1.33)	3.64- 8.27	27% (26)	.18- .36	1 $p < .000$
Youngest	25	4.33 (.51)	3.64- 5.07	24% (6)	.06- .42	$p = .015$
2nd youngest	26	5.53 (.32)	5.13- 6.12	23% (6)	.06- .4	$p = .009$
2nd oldest	26	6.73 (.38)	6.22- 7.43	23% (6)	.06- .4	$p = .009$
Oldest	20	7.85 (.21)	7.49- 8.27	40% (8)	.16- .64	$p = .503$