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Counterfactual curiosity in preschool children

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ABSTRACT

We investigated whether young children are curious about what *could have been* ("counterfactual curiosity"). In two experiments, children aged 4 and 5 years ($N = 32$ in Experiment 1, $N = 24$ in Experiment 2) played a matching game in which they turned over cards in the hope that they matched a picture. After choosing a card, children could use "x-ray glasses" to uncover unchosen cards. In Experiment 1, most children spontaneously used the glasses to peek at past alternatives, even when the outcome could no longer be altered. In Experiment 2, children concentrated their information search on alternatives that were within their control. In both experiments, children showed greater interest in counterfactual outcomes when the card they chose turned out not to match the picture. The findings suggest that young children are curious not only about what is but also about what could have been. Curiosity about alternative outcomes seems to precede counterfactual reasoning.

Introduction

Young children are naturally curious. They notoriously ask "why" questions in search of explanations (Callanan & Oakes, 1992; Frazier, Gelman, & Wellman, 2009), ask how things work (Corriveau & Kurkul, 2014), and explore the properties and functions of objects (Kemler Nelson, Egan, & Holt, 2004; Schulz & Bonawitz, 2007). Curiosity has been defined as a "thirst for knowledge" (Freud, 1925, p. 153)

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not for instrumental reasons but rather for its own sake (Berlyne, 1954; Loewenstein, 1994). Being curious has evolutionary advantages because it promotes learning in unknown environments (Kidd & Hayden, 2015; Oudeyer & Smith, 2016).

A classic view defended by, among others, William James maintains that children's curiosity is aroused by "every new impression that assails them" (James, 1899, 1925, p. 43), especially by things that are "bright, vivid, and startling" (p. 43). But when does children's curiosity reach beyond the immediate environment to explore unrealized possibilities? At some level of cognitive maturity, agents wonder how biographical and historical events would have played out if unrealized possibilities had prevailed (Shani, Tykocinski, & Zeelenberg, 2008; Tetlock & Belkin, 1996). "Counterfactual curiosity" is important because it allows us to learn from the past and improve our decision making going forward. It has been measured in adults by studying their search for information about foregone alternatives. Summerville (2011) had participants make choices based on limited knowledge such as selecting a card in a gambling game. After learning the outcome of their choices, participants frequently looked for information about foregone choice options—as though they wanted to know what they *would have gotten* had they chosen otherwise (see also Bault, Wydoodt, & Coricelli, 2016). These studies indicate that adults are keen to learn about missed opportunities. Their information seeking is an expression of curiosity because it is not driven by the prospect of immediate practical gain.

Adults' backward-looking search for knowledge shares two important features with counterfactual *reasoning*, that is, thinking about alternatives to past events or "what might have been" (Epstude & Roese, 2008). First, in gambling tasks, adults look longer (Bault et al., 2016) and more frequently (Summerville, 2011) at alternative outcomes after negative events than after positive events, suggesting that they are interested in whether things could have turned out better. Both adults (Kahneman & Miller, 1986; Markman, Gavanski, Sherman, & McMullen, 1993) and children (German, 1999; Guajardo, McNally, & Wright, 2016) also contemplate counterfactuals most frequently when negative events occurred—presumably to determine if and how a better world state could have developed. Second, adults are especially curious about alternatives that they had the power to bring about. In Bault et al. (2016) study, adults looked longer at lottery outcomes that they missed by choice rather than by chance. This controllability effect has also been shown to pervade counterfactual reasoning. Adults preferably mutate antecedents whose content concerns their own past actions and decisions (Girotto, Legrenzi, & Rizzo, 1991; Roese, Smallman, & Epstude, 2017); and both adults (Zeelenberg, Van Dijk, & Manstead, 1998) and school-age children are more prone to counterfactual emotions like regret when they feel responsible for what happened (O'Connor, McCormack, Beck, & Feeney, 2015; Weisberg & Beck, 2012). Considering counterfactual scenarios, either through information seeking or through reasoning, is critically important when faced with negative and controllable events because such counterfactuals help agents learn to foresee and possibly prevent the future occurrence of such events (Epstude & Roese, 2008; Taylor, 1991).

While nothing is known about children's counterfactual curiosity, the development of counterfactual *reasoning* has received considerable attention (Beck & Riggs, 2014; Rafetseder & Perner, 2014). Its age of onset is debated, with some claiming its presence by the end of infancy (Buchsbaum, Bridgers, Weisberg, & Gopnik, 2012) and others locating its emergence during late elementary school (Rafetseder, Schwitalla, & Perner, 2013). Many 3- and 4-year-olds respond accurately to questions about events that did not prevail, for example, whether a tree would be standing if the storm that blew it over had not occurred (Harris, German, & Mills, 1996). However, before 6 years of age, such reasoning is not bounded by the constraints of the real world, a crucial element of adult-like counterfactual reasoning (Lewis, 1973). This is particularly evident when basic knowledge of conditional relations (e.g., "if rain, then wet grass/if no rain, then dry grass"; see Rafetseder et al., 2013) does not yield the right answer, for example, when events are doubly determined (Nyhout, Henke, & Ganea, 2017) or do not conform to behavioral regularities (Rafetseder & Perner, 2010). It is now fairly commonly agreed that when false positives are carefully ruled out (Leahy, Rafetseder, & Perner, 2014), children younger than 6 years struggle with these more demanding counterfactuals (Beck, 2016; Rafetseder & Perner, 2018).

We conjecture that children become counterfactually curious before they meet the strict criteria for counterfactual reasoning. When reasoning contrary to fact, a reasoner imagines a premise that she or he knows to be factually false as being true and then specifies what the world would be like

under that hypothesized premise (Lewis, 1973). Being curious manifests in action, not judgment, and so is not tied to these logical rules and truth evaluations and does not require advanced language skills (e.g., pluperfect and subjunctive in English; see Iatridou, 2000). Unlike the reasoner who mentally constructs a nearest possible world, the curious agent simply explores what such a world looks like. By tracing past possibilities, she or he collects the empirical material for the content of counterfactual thoughts. Properly assessing the quality of one's choices typically involves a comparison of one's choice with its alternatives. But agents often need to make decisions without knowing much about their options. Counterfactual curiosity addresses this problem, if only ex post. By gathering knowledge about past alternatives, agents survey the spectrum of possibilities and adopt an ideal position from where they can evaluate their choices in light of the alternatives. In doing so, young children prepare themselves for counterfactual reasoning; vice versa, once children begin to reason counterfactually, they will mostly explore those alternatives that they expect to actualize under the hypothesized premises.

The current experiments

This is the first empirical inquiry into counterfactual curiosity in children. Because we suspected that counterfactual curiosity develops prior to counterfactual reasoning, we tested preschoolers around their fifth birthday, before they reason counterfactually according to strict criteria. In two experiments, we investigated whether young children are counterfactually curious and whether their curiosity is subject to the same biases as counterfactual reasoning. Children played a modified version of a card matching game designed by Moll, Pettit, Litvinova, Min, and Dehghani (2019) in which face-down cards needed to be turned over with the goal of matching them to a picture. After turning over a card, children could use "x-ray glasses" to peek under an unchosen card. The glasses use served as an index for counterfactual seeking. Experiment 1 investigated whether children *spontaneously* seek counterfactual information by making glasses use optional. Children's seeking was compared after positive versus negative outcomes and when they could "replay" trials (Redo condition) versus when they could not replay trials (No Redo condition). If children's search for information serves a purely practical function, then they should engage in such seeking only in the Redo condition. If, by contrast, children seek information out of curiosity, then their search should not depend on the opportunity to "fix" poor choices.

Experiment 2 addressed the problem that children might simply be curious about every stone that is left unturned without being specifically curious about outcomes they could control. We modified the procedure such that children needed to decide whether to use the x-ray glasses to reveal a card that had previously been available for choice or one that had been unavailable. This allowed us to test whether children are not indiscriminately curious about all kinds of "unknowns" but rather driven to find out what would have happened if they had made an alternative decision. If children preferably peek at unchosen cards, then their curiosity is indeed counterfactual and motivated by learning because it concentrates on unactualized events in which they chose differently.

Experiment 1

Method

Participants

Participants were 32 children (16 female) aged 4 and 5 years (M = 59;26 [months;days], range = 55;24–63;26) from a large city in the United States. A minimum sample size of 32 was required to detect a medium effect (determined using G*Power 3.1: Faul, Erdfelder, Lang, & Buchner, 2007; effect size based on previous studies: German, 1999; Guajardo et al., 2016). In terms of race, 17 children were White, 5 were Asian, 1 was African American, and 9 were "other." They either were recruited from the research laboratory's database of families and tested in the lab (n = 2) or were recruited and tested at local children's museums (n = 30). Children came from families with annual incomes ranging from less than $20,000 to more than $120,000. They received a small gift for

participation. An additional 3 children were tested but were excluded due to uncooperativeness ($n = 2$) or experimenter error ($n = 1$).

Materials

The matching game was written in MATLAB using the Psychophysics Toolbox extensions (Brainard, 1997) and presented on a 17-inch laptop computer. Children's responses were recorded using a touchpad. Whenever children chose a matching card, they moved a glow-in-the-dark star from the source bowl on the left of the laptop to the outcome bowl on its right. The cards showed various images of animals, fruit, colors, and activities.

Procedure

The trial procedure of the matching game is depicted in Fig. 1. On each trial, children were presented with a reference picture and two face-down cards on the computer screen. The aim of the game was to choose cards that matched the picture to win stars. Children chose a card by clicking on it, and that card either matched the picture (a positive outcome) or did not match the picture (a negative outcome). The x-ray glasses then appeared on the screen. These could be passed over the unchosen card to reveal it or returned to the case to complete the trial. Then the screen showed feedback based on the outcome of the trial, and children transferred a star from the source bowl to the outcome bowl and vice versa on positive and negative trials, respectively. Finally, in the No Redo condition, a green arrow appeared alone on the screen and could be used to start the next trial. In the Redo condition, a black "redo button" also appeared and could be used to replay the last trial with the same cards again; thus, children had the opportunity to revise their choices.

Prior to playing the matching game, children were shown the x-ray glasses. The experimenter (E) showed children how the glasses could be moved around the screen, used to peek at cards, and placed in their case to end a trial. Then the matching game was demonstrated to children. Use of the glasses was not demonstrated within the context of the matching game. Instead, the unchosen card was revealed automatically 5 s after the chosen card was revealed. E completed one trial, and then children completed a further four demonstration trials, one with each combination of the chosen and unchosen cards matching or not matching. E instructed children and commented on whether each card

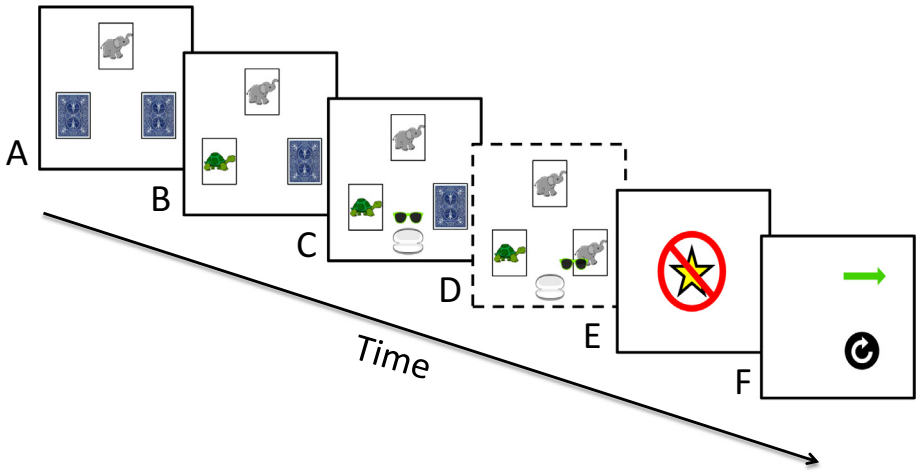

Fig. 1. Experiment 1: Matching game procedure. (A) The child turns over a card. (B) The outcome is revealed (e.g., negative: the chosen card does not match). (C) The x-ray glasses and case appear. (D) If glasses are moved to the unchosen card, its image is revealed (e.g., the unchosen card matches). (E) Feedback is given and a star is transferred. (F) In both the Redo and No Redo conditions, the green arrow button is used to move to the next trial. In the Redo condition, the child can use the black redo button to replay the trial. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

matched. In the last two demonstration trials, E demonstrated use of the redo button to replay the trial with the same cards.

During the test phase, the Redo and No Redo conditions were each presented in separate blocks of 16 trials each. Condition order was balanced between children, and children were informed prior to each block whether they would be able to revise their choices in the upcoming trials. Within each condition, 8 trials had a positive outcome and 8 trials had a negative outcome. The outcomes were pseudorandomized so that no more than 3 consecutive trials could be negative so as to reduce frustration. The unchosen card matched the picture on half of the trials, balanced across positive and negative outcomes, but was revealed only if the child passed the glasses over this card. This meant that both cards or neither card could match the picture, so children could not infer the status of the unchosen card from the chosen card. E did not comment on the game but rather was disengaged and quiet throughout the test phase. The entire procedure lasted 20–25 min.

Data analysis

Logistic mixed-effects models were fit to children's binary responses (glasses use or redo button use) using the "glmer" function from the *lme4* package (Bates, Maechler, Bolker, & Walker, 2014) in the R statistical language (http://www.r-project.org/). Each model included participant as a random effect and random slopes for each predictor in the model. Model complexity was reduced by forcing the correlation parameters of the random effects to zero to deal with issues of nonconvergence (Matuschek, Kliegl, Vasishth, Baayen, & Bates, 2017).

Results

Glasses use

A total of 24 children (75%) used the glasses to peek at the unchosen card on at least 1 trial. Children varied in the extent to which they used the glasses. Of those who used the glasses, 6 children used the glasses on fewer than 25% of trials and 11 children used the glasses on more than 75% of trials. Neither age nor gender predicted rates of glasses use.

Fig. 2 shows the proportions of trials in which children used the glasses as a function of condition and outcome. To determine the effects of condition (Redo vs. No Redo) and outcome (positive vs.

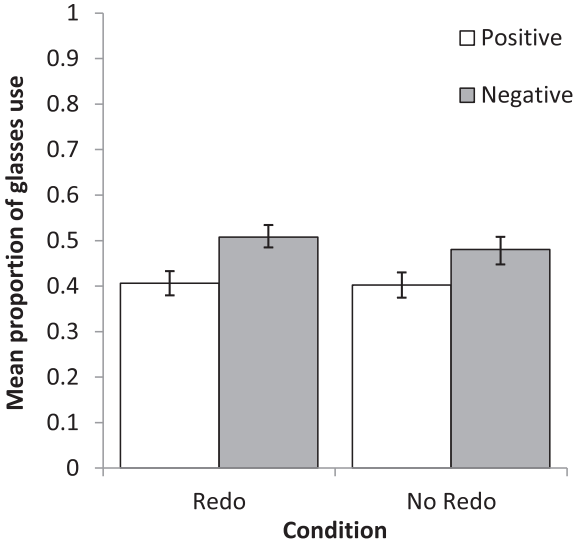

Fig. 2. Experiment 1: Children's use of the x-ray glasses as a function of outcome and condition. Error bars represent standard errors of the mean adjusted to account for between-participant variability using the method described by Cousineau (2005).

negative) on children's use of the glasses, null, main-effects, and interaction models were compared using the likelihood ratio test. The main-effects model provided the best fit to the data. Condition had no effect on children's glasses use, $\beta = 0.41$, $SE = 0.63$, $z = 0.65$, $p = .51$. Outcome, however, had a significant effect; children used the glasses more often after negative outcomes than after positive outcomes, $\beta = -1.29$, $SE = 0.34$, $z = -3.81$, $p < .001$. Including condition order in the analysis did not improve model fit, nor did it alter the main effects.

Redo button use

A total of 27 children (84%) used the redo button at least once to go back and change undesirable outcomes. We asked whether children made effective use of the information gained with the glasses if given the chance to revise prior choices, as has been reported in past research (Moll et al., 2019). To this end, we compared how often, after a negative outcome, children replayed trials when discovering that the unchosen card matched (so that there was an opportunity to improve the outcome) compared with when the unchosen card did not match (so that the negative outcome was inevitable). Previously, 4- and 5-year-olds have been shown to make such wise choices in a similar task (Moll et al., 2019). This analysis included only trials in the Redo condition with a negative outcome on which the glasses were used (so that children had seen the unchosen card), a total of 130 trials across 21 participants. As expected, children revised their previous choices more often when the unchosen alternative matched the picture and their choice could be revised for the better (58%) than when the alternative card did not match and the negative outcome was inevitable (31%), $\beta = 1.45$, $SE = 0.67$, $z = 2.15$, $p = .031$.

Discussion

In this experiment, 4- and 5-year-olds spontaneously used x-ray glasses to peek at foregone alternatives. Their informational search did not vary depending on the possibility to rectify poor choices. Children peeked at past alternatives regardless of whether there was a prospect of correcting unfavorable choices. Thus, their search behavior was an expression of curiosity that, per definition, seeks knowledge for its own sake without expecting immediate instrumental gain. Children also showed a slight but robust negativity bias by exploring alternatives more often after negative outcomes (49%) than after positive outcomes (40%).

One might object that children's exploration of unrevealed cards shows only that children are generally curious about whatever remains unrevealed (any face-down cards). More convincing evidence is needed to show that, instead, children are *counterfactually* curious, that is, curious about what did not happen but realistically could have happened. This criticism was addressed in Experiment 2, where we aimed to support the view that children are not indiscriminately curious about whatever remains unknown but rather are *selectively* curious about unrealized choice options that they could have secured.

Experiment 2

The experimental design of the second experiment was changed to test whether children hone their curiosity on events they could have brought about by choice. By 4 years of age, children understand the difference between situations that they can willfully change and those that they cannot influence (Kushnir, Gopnik, Chernyak, Seiver, & Wellman, 2015). If children are specifically curious about possibilities that they could have caused, then they should concentrate their search on alternatives that are within their action control while ignoring alternatives that lay outside the realm of their influence. Thus, we modified the design so that children were forced to reveal either a card that had been available to them to choose or a card that had been unavailable as a choice option. In step with the hypothesis that children are curious about what would have happened had they acted otherwise, we predicted that they would prefer peeking at cards they could have chosen.

Method

Participants

Participants were 24 children (12 female) aged 4 and 5 years (M = 59;12 [months;days], range = 56;11–63;11). A minimum sample of 20 was required to detect a medium–large effect (determined using G*Power 3.1: Faul et al., 2007; effect size based on Experiment 1 and previous research examining the effect of children's control over an event on their counterfactual emotions: Weisberg & Beck, 2012). Because glasses use was mandatory in this experiment, the sample size matched the number of participants who used the glasses in Experiment 1. In terms of race, 11 children were White, 4 were Asian, 3 were African American, and 6 were "other." Children were tested in the lab (n = 3), in a children's museum (n = 16), or at preschool (n = 5). The children's families' annual household incomes ranged from less than $20,000 to more than $120,000. An additional 2 children were tested but were excluded because of uncooperativeness (n = 1) or experimenter error (n = 1).

Materials

The materials were identical to those used in Experiment 1.

Procedure

The trial procedure was modified from Experiment 1 in the following ways. Instead of the two cards, *three* cards were shown side by side below the picture. Importantly, the range of options for choice, prior to glasses use, was systematically constrained. A green or red traffic light appeared on each card, symbolizing its availability; a green light indicated that a card was available as a choice option, and a red light indicated that it was unavailable. These traffic light cues were removed when children chose a card. After children made a choice and saw its outcome, glasses use was mandatory and limited to a single card. Children needed to decide which of the two remaining cards they wished to reveal with the glasses.

There were two conditions. In the Choice condition, two cards were available for choice and the third card was unavailable. Thus, children could choose to seek information about a previously available card or a previously unavailable card. In the No Choice condition, only one card could be turned and the other two cards were unavailable. Thus, children could seek information only about previously unavailable cards. The conditions are illustrated in Fig. 3. The No Choice condition served two functions. First, it served as a spatial control for the Choice condition. This was necessary because children's initial card selection dictated the spatial positions of the two remaining cards in the Choice condition. This spatial control function was achieved by yoking the position of the available card in each No Choice condition trial to the position of the selected card in a previous Choice condition trial. Second, inclusion of the No Choice condition gave children experience at using the glasses to look at previously unavailable cards, thereby demonstrating that the glasses were effective and their use was permitted even if the card had not previously been available for choice. It was expected that children would perform at chance in the No Choice trials because the only difference between the two cards was their spatial position.

Prior to the matching game, children were shown how to use the x-ray glasses to reveal a card on the screen. Then the matching game was demonstrated to children. E explained the traffic light symbols, and demonstrated that a card with a red traffic light could not be chosen. E completed one demonstration trial in which the unchosen cards were revealed automatically. Children then completed four demonstration trials in the following order: No Choice–positive, Choice–negative, Choice–positive, and No Choice–negative. In each trial, after children had chosen a card, the glasses appeared on the screen and E declared, "Now you can use the glasses to peek at one of the other cards." Children moved the glasses over one of the two unchosen cards, and it was revealed.

The test phase consisted of a single block of 18 trials, with the Choice and No Choice conditions presented in a mixed design. Within each condition, there were 3 positive trials and 6 negative trials. Positive trials led to the gain of two stars; negative trials led to the loss of just one star. This was decided to prevent children from running out of stars. In half of the negative trials, the card that was revealed with the glasses matched the picture; in the other half, the card did not match. The trial order was pseudorandomized, with a maximum of 3 consecutive negative trials. The yoking of trials

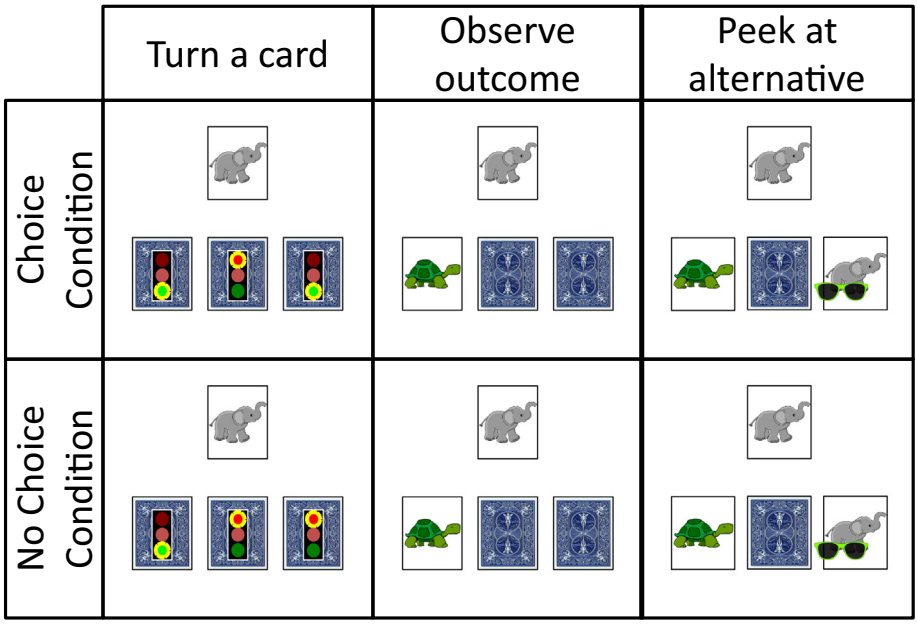

Fig. 3. Experiment 2: Main procedural steps as a function of condition. In the Choice condition, two cards have green traffic lights and can be turned over. In the No Choice condition, only one card has a green traffic light and can be turned over. After a card has been turned, its outcome is revealed and then the glasses are used to peek at one of the remaining cards.

further constrained the randomization in the following manner: The first trial was always a Choice trial, the last trial was always a No Choice trial, and in between the number of Choice trials that had been run always exceeded the number of No Choice trials. Unlike in Experiment 1, there was no opportunity to replay trials. The entire procedure lasted 15–20 min.

Results

We used logistic mixed-effects regression models to compare how often children peeked at previously available cards in the Choice condition with how often they peeked at spatially analogous cards in the No Choice condition. For clarity of reference, these cards are hereafter labeled "target cards." Fig. 4 shows the proportions of target cards children peeked at as a function of condition and outcome. To determine the effects of condition (Choice vs. No Choice) and outcome (positive vs. negative) on children's use of the glasses to peek at the target card, null, main-effects, and interaction models were compared using the likelihood ratio test. There was a significant main effect of condition, $\beta = 1.63$, $SE = 0.22$, $z = 7.41$, $p < .001$, with children peeking at previously available alternatives in the Choice condition more often than at spatially analogous cards in the No Choice condition. There was also a significant main effect of outcome, $\beta = -0.56$, $SE = 0.23$, $z = -2.47$, $p = .014$, with children peeking at the target card more often after negative outcomes than after positive outcomes. Including the interaction term improved the model's fit to the data. The main effects were qualified by a significant interaction between condition and outcome, $\beta = -1.20$, $SE = 0.46$, $z = -2.63$, $p = .009$. Post hoc models run over each condition with Bonferroni-adjusted alpha values (.025) showed that there was an outcome effect in the Choice condition but not in the No Choice condition; only when children had chosen a card (and, thus, rejected another card) did they peek at target cards more after negative outcomes (87%) than after positive outcomes (65%), $\beta = -1.25$, $SE = 0.34$, $z = -3.59$, $p < .001$. Note that in the No Choice condition, neither of the two unrevealed cards was previously available for choice. As

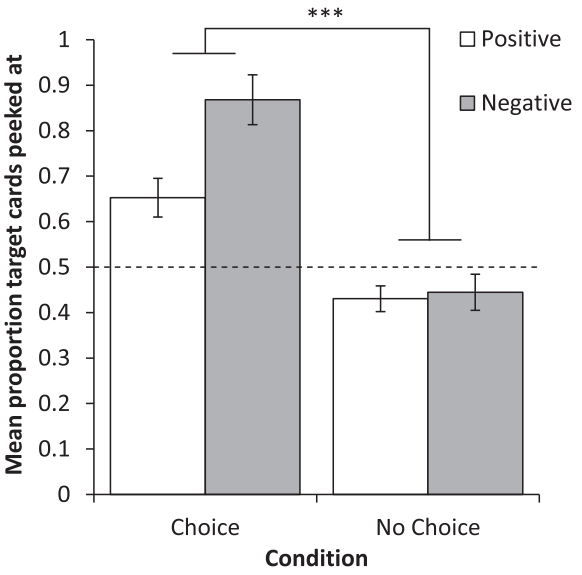

Fig. 4. Mean proportions of available cards peeked at by condition and outcome. Error bars represent standard errors of the mean. $^{***}p < .001$.

expected, outcome had no effect on children's glasses use in this condition, $\beta = -0.06$, $SE = 0.29$, $z = -0.19$, $p = .85$.

Discussion

These results support the hypothesis that young children, when looking back at past events, are not indiscriminately curious about various alternatives to reality. Rather, they are especially curious about possibilities that they could control and would have become reality if children had chosen them. They concentrate on "the road not taken"—at the expense of more remote alternatives that were outside the field of their influence. This selectivity of children's curiosity is further intensified when what they chose turned out to be undesirable, leading them to wonder whether they could have done better.

One might object that children focused their curiosity on the unchosen card only because it was more salient than its alternative, with its saliency coming from the fact that children deliberated over this card when making their choice. The attention they had paid to this card during their decision making may have biased them toward this card when applying the glasses. The difference between this reductive account and the counterfactual account is subtle; the reductive account argues that children's selective use of the glasses is a mere spillover effect of their *earlier* preoccupation with a choice option, whereas the counterfactual account argues that it is an effect of children looking back and wondering about the content of this past option. Two considerations show why the counterfactual account is more plausible than the reductive account. First, there is no a priori reason why an alternative that figured as a choice option should be more salient than an alternative that was, for unknown causes, blocked from choice. One could just as well argue that the inaccessible card (the "forbidden fruit") was more salient due to its unavailability. Second, the reductive account is inconsistent with the fact that children were more selective in their search after discovering that their choice was unfavorable. If children's interest in the unchosen card is a pure carryover effect from their mental preoccupation with this card at choice, then no factors playing out post-choice—such as outcome valence—should bias their search. This, however, is precisely what was found; hence the results are more consistent with the counterfactual account.

General discussion

This study is the first to examine whether young children are curious about unrealized events. A novel information-seeking paradigm was designed in which children used x-ray glasses to identify foregone alternatives. In two experiments, children sought information about alternatives that did not, but could have, become reality. The results suggest that children aged 4 and 5 years are keen to uncover unrealized possibilities: They are inherently curious about missed opportunities.

In Experiment 1, most children (75%) spontaneously sought knowledge about foregone alternatives when it was up to them to do so. They used the glasses to peek at past alternatives regardless of whether the information gained with them could be used to improve reality. Thus, their search was a genuine manifestation of curiosity, which by definition strives for knowledge for its own sake (Loewenstein, 1994). From a pragmatic standpoint, it might be puzzling that children are somewhat indifferent to the practical value of knowledge. Two considerations remove this puzzlement. First, it typically remains to be seen for learners when and how the knowledge they acquire might turn out to be useful or applicable (Kidd & Hayden, 2015), and so a learning strategy that values knowledge in its own right, without expecting instant applicability, is beneficial. Second, children *do* exploit the practical benefit of knowledge when the opportunity arises; in 58% of cases, children used the information they gathered with the glasses to rectify poor outcomes when this was possible (Redo condition). Thus, children's curiosity certainly aids learning and practical reasoning without being motivated by the expectation of immediate practical benefits.

Children's backward-looking search bore two features suggesting that it is continuous with adults' interest in foregone alternatives. First, like adults (Bault et al., 2016; Summerville, 2011), children intensified their search after negative events. The obvious explanation is that children strived to learn how the undesirable event came about in the hopes to prevent its future recurrence (German, 1999). The pressure to learn is greatest in the wake of negative events. Second, children focused their search on those aspects of an event that were under their willful control. In Experiment 2, they predominantly peeked at alternatives that had been available choice options while showing little interest in alternatives that were never within their decisional reach. Adults also concentrate on prior decision points both in their retrospective search for information (Bault et al., 2016) and in their counterfactual reasoning (Roese et al., 2017). Together, these features suggest that children's quest for knowledge is driven by their curiosity about the circumstances they would have faced if they had made alternative decisions.

A pressing question is how children's curiosity about past alternatives relates to counterfactual reasoning. A child reasoning counter to fact determines how things would have turned out under particular hypothesized conditions. The child makes a truth-evaluable judgment (e.g., that the soccer ball would have drifted left if she or he had struck it on the right). Such judgment affords a great deal of familiarity with causal relations and is measured by strict logical constraints (e.g., the nearest possible world constraint; see Lewis, 1973)—none of which holds for being curious about what might have been. We might say that counterfactual reasoning (if done right) means knowing what would have happened, whereas counterfactual curiosity means exploring what would have happened.

Children exhibit curiosity about counterfactual world states before they can properly reason with them, which (if strict criteria are applied) is no sooner than around 6 years of age (Leahy et al., 2014; Rafetseder et al., 2013) or even later (e.g., if we look for *spontaneously* generated counterfactual statements; see Guajardo et al., 2016). Despite the differences in cognitive demands, counterfactual curiosity and counterfactual reasoning share the same biases; both tend to be kickstarted by negative and controllable events, suggesting that both are geared toward an understanding of how a better world state may have been achieved. We surmise that counterfactual curiosity and counterfactual reasoning feed into each other's development. The exploration of alternatives that almost became reality provides young children with the empirical content needed to form counterfactual consequents (e.g., "I would have gotten a matching card"). Once children exercise counterfactual reasoning, they will probably tend to seek empirical confirmation for their judgments by exploring hypothesis-congruent alternatives.

As the first investigation of children's counterfactual curiosity, this study leaves some important questions unanswered. First, it sheds no light on the developmental trajectory of this phenomenon because it involves a single age group. Future research should compare different ages and include younger children to trace when children first become curious about counterfactuals and how this curiosity develops over time. Second, individual differences in children's search behavior remain unexamined. The extent to which alternative possibilities were explored varied greatly between children. (In Experiment 1, 25% of children did not use the glasses at all, and 34% of children used them on more than 75% of trials.) Cross-sectional and longitudinal work could illuminate the personality traits of children who are keen to explore foregone alternatives (e.g., openness to experience) and how this relates to their affective responses when these alternatives are revealed. Lastly, it is key to generate future research on the developmental relation between counterfactual curiosity and counterfactual reasoning. More specifically, one could test whether counterfactual curiosity precedes and prepares counterfactual reasoning and, once children can reason counterfactually, whether the two feed into each other in the way we sketched out above.

To conclude, preschool children gather knowledge about past alternatives to find out what they missed even when they cannot apply this knowledge to alter reality. This is important evidence that young children do not just itch to learn more about whatever assails them here and now (James, 1899, 1925). Rather, they seek selective knowledge, including knowledge about alternatives to reality. Of greatest interest to them are alternatives they could have brought about by their own choosing. Exploring unrealized choice options allows them to survey the field of possibilities, review their decisions in light of the alternatives, and learn more about the consequences of their actions.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jecp.2018.11.022.

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