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## Brief Report

# Counterfactually mediated emotions: A developmental study of regret and relief in a probabilistic gambling task

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## ABSTRACT

Regret and relief are related to counterfactual thinking and rely on comparison processes between what has been and what might have been. In this article, we study the development of regret and relief from late childhood to adulthood (11.2–20.2 years), and we examine how these two emotions affect individuals' willingness to retrospectively reconsider their choice in a computerized monetary gambling task. We asked participants to choose between two "wheels of fortune" that differed in the amount of gain and loss expected and the probability of winning. We manipulated the outcome of the wheel of fortune that was not selected by participants to induce regret or relief. For each trial, participants rated how they felt about the outcome and their willingness to modify their choice. Participants' ratings suggest that regret and relief are stronger in adults than in children and adolescents. Regret affects participants' willingness to modify their initial choice, but this desire is stronger for adults than for children. In children, the experience of regret seems to be dissociated from the willingness to reconsider a choice. This study provides the first evidence that the ability to experience counterfactually mediated emotions, such as regret and relief, and the ability to take them into consideration continue to develop during late childhood and adolescence.

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## Introduction

Psychology and neuroscience studies have provided converging evidence that emotion plays a crucial role in adaptive decision making (Cassotti et al., *in press*; Loewenstein, Rick, & Cohen, 2008). As suggested by Zinck and Newen (2007) (see also Power, 2010), emotions can be classified into basic and nonbasic emotions. During emotional development, basic emotions (e.g., fear, anger, joy, sadness) are differentiated into more complex cognitive emotions. Among these cognitive emotions, some emotions (e.g., regret, relief) are related to counterfactual thinking (Ritov, 1996). Specifically, these emotions rely on comparison processes between what has been and what might have been (Byrne, 2002). An individual experiences regret (upward counterfactual thinking) when the actual outcome of his or her choice is worse than the outcome of the rejected alternative, whereas the individual experiences relief (downward counterfactual thinking) in the opposite situation. Counterfactually mediated emotions result directly from an individual's decision (Mellers, Schwartz, & Ritov, 1999; Weisberg & Beck, *in press*) and, thus, are necessarily associated with a high feeling of responsibility.

Regret and relief are emotions that have a significant impact on everyday life. They can explain, among other things, irrational decision making such as the appetite for games (Zeelenberg & Pieters, 2004). However, few studies have examined the development of such counterfactually mediated emotions. This is particularly true for adolescence, even though adolescence is known to be a critical period for risk taking (Steinberg, 2008). Consequently, the goal of this study was to uncover the development of regret and relief from late childhood to adulthood and to examine how these two emotions modulate the willingness to reconsider an individual's choice.

To date, developmental psychology has focused mainly on the development of counterfactually mediated emotions in young children. For example, in Weisberg and Beck's (2010) paradigm, 5- to 8-year-olds were asked to choose between two boxes before the outcome obtained on the selected box and the unobtained outcome (on the unselected box) was revealed. By a manipulation of the unobtained outcome, researchers induced regret (when the unobtained outcome was better than the obtained outcome) or relief (in the opposite case). Finally, the children rated how they felt on a 5-point "emotional" Likert scale. Analysis of the ratings revealed that the acquisition of regret and relief occurs at different ages; the experience of regret develops at around 5 years of age, whereas the experience of relief does not develop before 7 years of age (Ferrell, Guttentag, & Gredlein, 2009; Guttentag & Ferrell, 2008; O'Connor, McCormack, & Feeney, 2012). According to Weisberg and Beck (2010), the fact that relief is experienced later than regret could reflect a bias of children's counterfactual thinking; adults show a greater tendency to think counterfactually when the outcome obtained is negative. Nevertheless, the authors noted that their task might not have led to "genuine relief" because the children were never confronted with an alternative negative outcome.

Recently, the development of regret and relief during adolescence and the impact of these emotions on decision making were investigated in a probabilistic gambling task with both positive and negative outcomes (Burnett, Bault, Coricelli, & Blakemore, 2010). Regret and relief were induced in the same way as in Weisberg and Beck's (2010) paradigm, using a manipulation of the unobtained outcome relative to the obtained outcome. Participants' emotional ratings revealed that relief, but not regret, develops during adolescence. The lack of development of regret during adolescence is surprising given what is known about the maturation of the brain areas involved in regret. Indeed, increasing feelings of regret are positively correlated with enhanced activity in the orbitofrontal cortex (OFC), an area that continues to mature until late adolescence (Camille et al., 2004; Chua, Gonzalez, Taylor, Welsh, & Liberson, 2009; Coricelli, Dolan, & Sirigu, 2007).

A possible explanation of the lack of evidence for the development of regret during adolescence might relate to the nature of the dependent variables used to study regret. Studies have focused primarily on emotional ratings. Given that counterfactually mediated emotions are closely related to the alternative chosen by participants, it is necessary to also consider the degree to which participants are willing to modify their initial choice after experiencing regret (see Chua et al., 2009). Thus, the choice rating could be a complementary measure of counterfactual thinking. Interestingly, neuroimaging investigation of regret and relief has recently confirmed the complementarity of both scales (Chua et al., 2009). The data revealed positive correlations between the desire to change an initial

choice in a gambling task and activations of the anterior cingulate cortex and the ventromedial prefrontal cortex, whereas these specific brain regions are not associated with the emotional experience of regret or relief. Interestingly, these regions are usually involved in conflict detection and executive correction of previous errors (Houdé & Tzourio-Mazoyer, 2003; Houdé et al., 2001).

To examine the development of regret and relief in the current study, children (10–12 years), adolescents (13–15 years), and adults (18–24 years) participated in a new child-friendly gambling task adapted from Camille et al. (2004) (see also Mellers et al., 1999). For each trial, participants chose between two gambles depicted as “wheels of fortune.” The outcomes of the wheel of fortune that participants selected (the obtained outcome) and of the one they did not select (the unobtained outcome) were presented. Participants rated not only how they felt about the comparison between the obtained outcome and the unobtained outcome (i.e., an “emotional” rating scale) but also the extent to which they were willing to change their initial choice (i.e., a “choice” rating scale).

According to previous studies (Ferrell et al., 2009; Weisberg & Beck, 2010), the experience of regret and relief is already developed at around 7 years of age. However, if the OFC has a fundamental role in the experience of regret, and given the late maturation of this brain area, we expect to observe a progressive development of the emotional experience of counterfactual emotions from childhood to adulthood—where this experience should reach its maximum level. In addition, choice ratings may provide critical information (a) to study the developmental trajectories of regret and relief and (b) to understand the complexity of these two counterfactual emotions. Taking into consideration both emotional and choice ratings should allow us to more accurately assess two essential and complementary components of regret and relief: the experience of these emotions and their impact on the willingness to modify or maintain a choice.

## Method

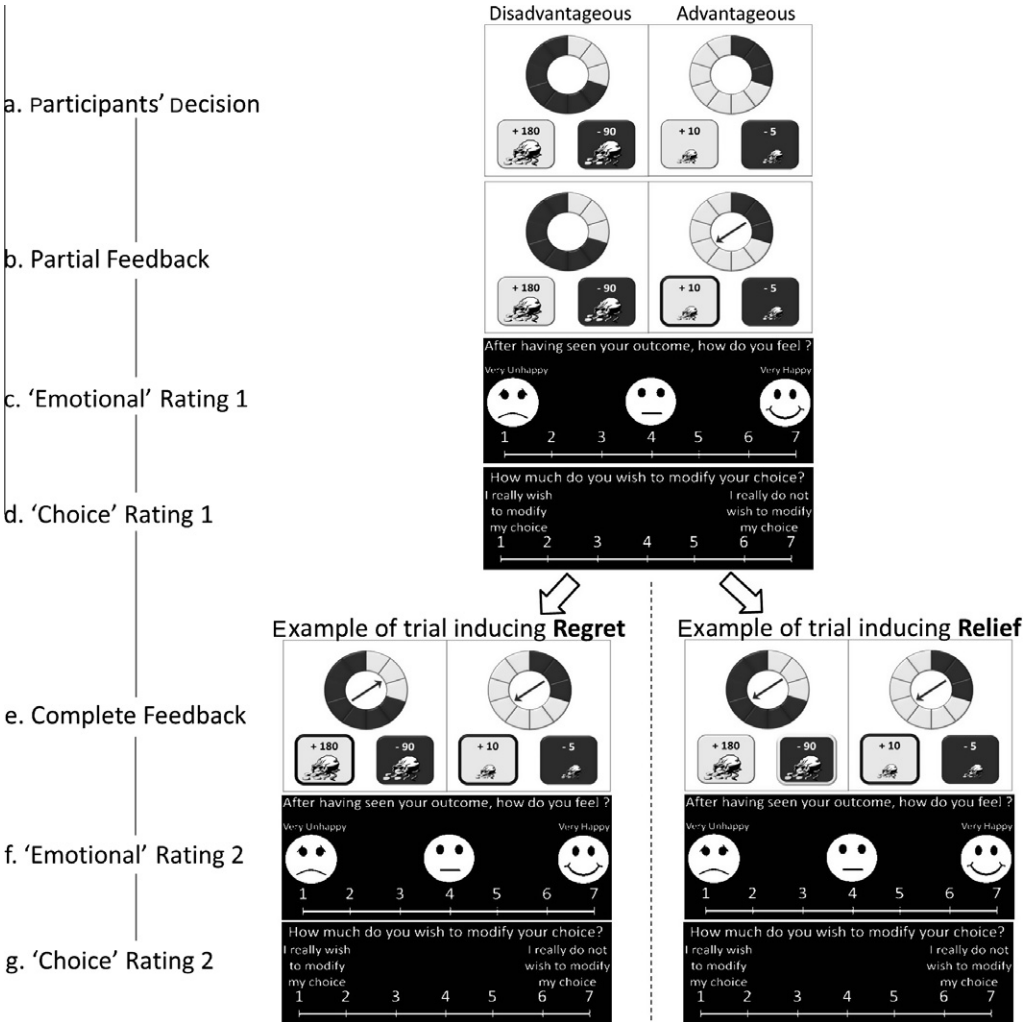
### *Participants*

A total of 53 volunteers participated in this experiment. To examine developmental changes, we recruited participants from three age groups: 19 children (mean age = 11.2 years, SD = .66), 17 adolescents (mean age = 14.5 years, SD = .40), and 17 university psychology students (mean age = 20.2 years, SD = 1.48). Written parental consent was obtained for children and adolescents prior to the assessment session. Participants were tested in accordance with national and international norms governing the use of human research participants.

### *Materials and procedure*

The task was computer-based. Participants performed 36 trials of a gambling task involving imaginary monetary wins and losses and were asked to earn as much money as possible. To induce counterfactually mediated emotions, participants were required to choose between two gambles depicted as “wheels of fortune” displayed on a computer screen. Each wheel had 10 wedges that could be green or red—associated with a probability of gain or loss, respectively. Participants were invited to select one of the two wheels by clicking a mouse.

As in previous studies on decision making in children and adolescents (Van Leijenhorst, Westenberg, & Crone, 2008), participants were asked to choose between an advantageous wheel (with a positive expected value) and a disadvantageous but attractive wheel (with a negative expected value). The advantageous wheels offered small gains (+10 or +20) combined with small losses (−5 or −10) and a high probability of winning money (.70, .80, or .90). The disadvantageous but attractive wheels offered higher gains (+90 or +180) combined with higher losses (−45 or −90) and a low probability of winning money (.10, .20, or .30). All information that was relevant for making a decision was presented to participants in every trial. This design led to 36 possible combinations of wheels. The position (left or right) of the advantageous wheel and the disadvantageous wheel was counterbalanced over trials. The presentation of the gambles was randomized. After participants' choice (Fig. 1, step a), an outcome was selected according to the probabilities of gain and loss of the wheel selected.



**Fig. 1.** Experimental design of a trial inducing regret or relief. Two wheels of fortune are displayed on the computer screen. After participants' decision (a), a white arrow indicates the obtained outcome (partial feedback) (b). After seeing the outcome, participants must indicate how they feel (emotional rating) (c) and how much they wish to modify their choice (choice rating) (d). Next, a second feedback indicates the unobtained outcome (complete feedback) (e), and participants must make a second emotional rating (f) and a second choice rating (g).

Two types of feedback, *partial* and *complete* feedback, were provided to participants to experimentally induce disappointment and elation or regret and relief. The first feedback (partial feedback) was presented immediately after participants' choice when a white arrow appeared on the wheel selected by participants for 4000 ms, indicating whether participants won or lost money (Fig. 1, step b). Thus, the partial feedback induced either disappointment (in the case of losses) or elation (in the case of gains).

After the partial feedback, participants rated how they felt about the outcome on a 7-point "emotional" Likert scale (Fig. 1, step c) ranging from 1 (*I am very unhappy*) to 7 (*I am very happy*). Participants then rated the extent to which they wished to modify their initial choice on a 7-point "choice" Likert scale (Fig. 1, step d) ranging from 1 (*I really wish to modify my choice*) to 7 (*I really do not wish to*

modify my choice). In this second rating, participants did not actually have the opportunity to modify their choice but indicated how much they wished to reconsider it.

For the second feedback (complete feedback), an arrow appeared on the unselected wheel for 4000 ms (Fig. 1, step e). Thus, participants could compare the unobtained outcome with the outcome they obtained. The complete feedback induced either regret (when the comparison between the obtained and unobtained outcomes was unfavorable to participants) or relief (in the opposite case). As with the partial feedback, participants then completed the emotional and choice rating scales (Fig. 1, steps f and g).

Participants first performed two practice trials to become familiar with the sequence of events. After the practice trials, all participants were confident that they could perform the task. The duration of the task varied between 8 and 13 min, depending on participants' response times.

## Results and discussion

As a first step, we analyzed the proportions of advantageous and disadvantageous choices in each age group to determine whether children were biased toward advantageous wheels, which would demonstrate that children, like adolescents and adults, are able to choose advantageously.

Next, we separately analyzed the "emotional" and "choice" ratings for trials in which participants chose the advantageous wheels. We restricted our analyses to the advantageous choices because participants did not sufficiently choose disadvantageous wheels.

Participants' ratings in the complete feedback were analyzed in four outcome conditions for the advantageous choices: (a) *loss–loss condition*, where low loss on the selected wheel was associated with high loss on the unselected wheel, which should induce minimal relief; (b) *win–win condition*, where low win on the selected wheel was associated with high win on the unselected wheel, which should induce minimal regret; (c) *win–loss condition*, where low win on the selected wheel was associated with high loss on the unselected wheel, which should induce maximal relief; and (d) *loss–win condition*, where low loss on the selected wheel was associated with high win on the unselected wheel, which should induce maximal regret.

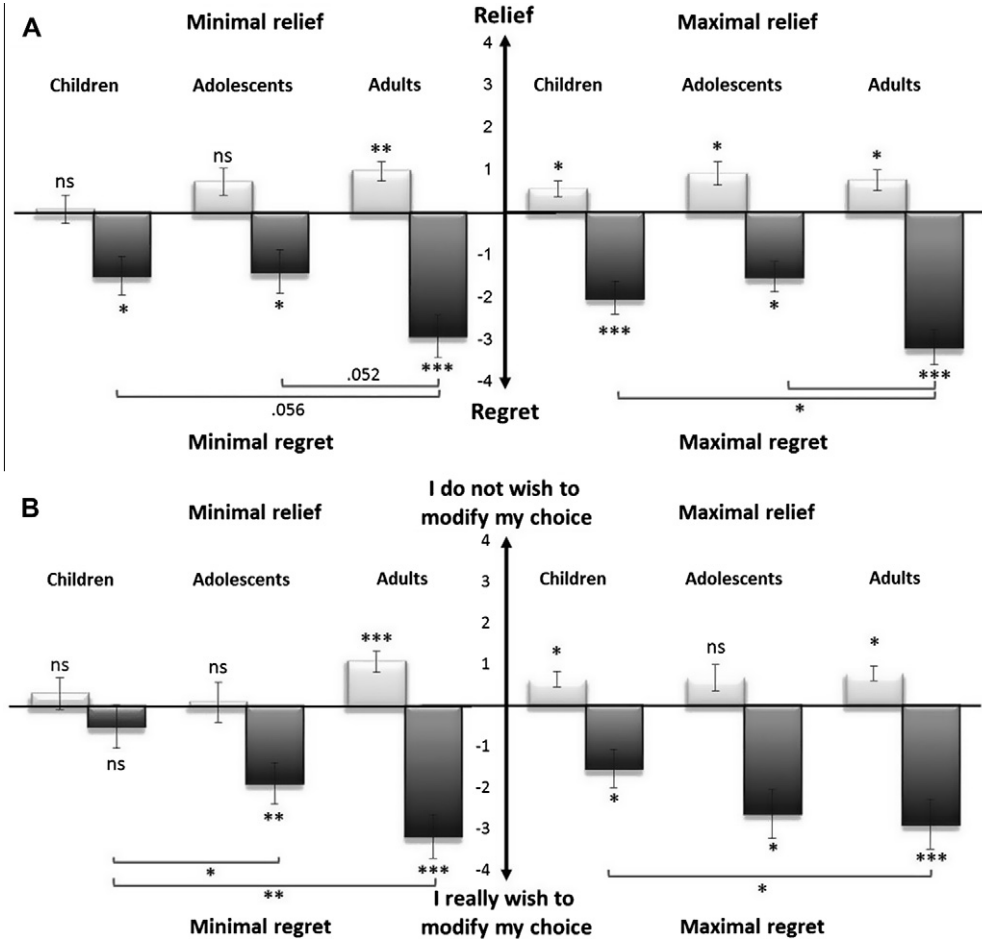
For the emotional and choice rating analyses, we computed difference scores (see Weisberg & Beck, 2010). Ratings on the partial feedback were subtracted from ratings on the complete feedback. Thus, the emotional and choice scores ranged between  $-6$  and  $+6$ . For the emotional scores, scores below zero reflected regret, and scores above zero reflected relief. For the choice scores, scores below zero reflected willingness to modify the initial choice, and scores above zero reflected willingness to maintain the initial choice.

### Risk taking

A one-way between-participants analysis of variance (ANOVA) on the proportion of advantageous choices revealed that children ( $M = 69\%$ ,  $SD = 20$ ), adolescents ( $M = 63\%$ ,  $SD = 23$ ), and adults ( $M = 63\%$ ,  $SD = 21$ ) did not differ in their risk-taking behavior,  $F(2, 50) < 1$ . Thus, children, like adolescents and adults, were able to choose advantageously. Notably, this result is consistent with the results reported by previous studies showing that there are no developmental differences in the ability to choose advantageously up to 8 years of age (Van Leijenhorst et al., 2008). Considering this result, any difference in the emotional and/or choice ratings cannot be attributed to differences in participants' performance on the gambling task.

### "Emotional" ratings

First, we carried out one-sample  $t$  tests for each of the four outcome conditions to determine whether the emotional scores differed from zero, which would suggest that participants experienced regret (for negative emotional scores) or relief (for positive emotional scores) (Fig. 2A). All  $p$  values were corrected with a Bonferroni procedure. Second, we conducted a mixed-design ANOVA on the emotional scores to study developmental changes.



**Fig. 2.** Emotional ratings (A) and choice ratings (B): Mean scores (partial feedback ratings subtracted from complete feedback ratings) on regret and relief conditions for advantageous wheels. Ratings were analyzed according to four types of outcome: minimal relief (loss–loss condition), minimal regret (win–win condition), maximal relief (win–loss condition), and maximal regret (loss–win condition). To study regret and relief, we compared regret and relief scores with zero (one-sample *t* tests with zero as the test value, Bonferroni-corrected at \**p* < .05, \*\**p* < .005, and \*\*\**p* < .001).

Emotional scores differed from zero in the minimal regret (win–win) and maximal regret (loss–win) conditions:  $M = -1.48$ ,  $t(18) = -3.73$ ,  $p < .01$  and  $M = -2.02$ ,  $t(18) = -4.80$ ,  $p < .001$  for children;  $M = -1.40$ ,  $t(16) = -3.15$ ,  $p < .05$  and  $M = -1.53$ ,  $t(16) = -3.81$ ,  $p < .01$  for adolescents; and  $M = -2.91$ ,  $t(16) = -5.39$ ,  $p < .001$  and  $M = -3.19$ ,  $t(16) = -7.85$ ,  $p < .001$ , for adults, respectively (Fig. 2A). Given that average emotional scores were negative in both conditions, the results strongly suggest that participants experienced regret regardless of their age. The expression of relief for adolescents was significant in the maximal relief condition,  $M = .91$ ,  $t(16) = 3.13$ ,  $p < .05$ , but failed to reach significance in the minimal relief (loss–loss) condition,  $M = .75$ ,  $t(16) = 2.39$ ,  $p = .09$ . In contrast, children expressed relief only in the maximal relief (win–loss) condition,  $M = .55$ ,  $t(18) = 2.89$ ,  $p < .05$ , whereas adults experienced relief in the minimal relief (loss–loss) condition,  $M = .98$ ,  $t(16) = 4.73$ ,  $p < .001$ , and the maximal relief condition,  $M = .75$ ,  $t(16) = 3.12$ ,  $p < .05$ . Missing data for a given condition were replaced by the mean of that condition for a given participant. Supplementary analyses revealed a similar pattern of results.



A 3 (Age: children vs. adolescents vs. adults)  $\times$  4 (Outcomes: loss–loss vs. loss–win vs. win–loss vs. win–win) mixed-design ANOVA on the emotional scores revealed that these scores differed among the three age groups,  $F(2, 50) = 3.24$ ,  $p < .05$ ,  $\eta_p^2 = .12$ , and among the four types of outcome,  $F(3, 50) = 57.95$ ,  $p < .001$ ,  $\eta_p^2 = .54$ . In addition, the age of participants affected the emotional scores differently in the four types of outcome,  $F(6, 150) = 2.73$ ,  $p < .05$ ,  $\eta_p^2 = .10$ . Critically, planned comparisons revealed that in the minimal regret condition, children's and adolescents' average emotional scores were lower than adults' scores,  $t(34) = -1.60$ ,  $p = .056$ ,  $d = .72$  for children and  $t(32) = -1.59$ ,  $p = .052$ ,  $d = .72$  for adolescents. Similarly, in the maximal regret condition, children's and adolescents' emotional scores were lower than adults' scores,  $t(34) = -2.41$ ,  $p < .01$ ,  $d = .70$  for children and  $t(32) = -3.47$ ,  $p < .001$ ,  $d = 1.75$  for adolescents.

Analyses of the emotional scores revealed developmental differences for both types of counterfactually mediated emotion (regret and relief). On the one hand, all participants experienced regret in the two outcome conditions designed to induce this emotion, but children's and adolescents' subjective experience of regret was reduced compared with that of adults. Although all groups reported relief in the win–loss condition designed to induce maximal relief, children did not experience significant relief when they lost a small amount of money but avoided losing a higher amount (loss–loss condition). This result should be moderated because the comparison between the minimal relief and maximal relief conditions is not significant in children,  $t(18) = 1.78$ ,  $p = .25$ .

The developmental results reported in the current study are consistent with the late functional maturation of the OFC (Gogtay et al., 2004), a brain area critical for experiencing counterfactually mediated emotions (Coricelli et al., 2007). The current results are also in line with a recent study indicating that the emotionally “hot” decision-making process (as was the case in our study) develops relatively slowly (Prencipe et al., 2011).

We observed developmental differences in the experience of regret, whereas Burnett et al. (2010) reported developmental differences only in the experience of relief. One explanation of this discrepancy might be related to the fact that, unlike Burnett and colleagues, we based our analyses on difference scores (see Weisberg & Beck, 2010) to properly evaluate the subjective feeling of regret and relief. Our results are consistent with those reported in a recent study (Rafetseder & Perner, in press) showing that regret develops progressively from childhood to adulthood and reaches its maximum level in the adult group.

The lack of relief in 10- to 12-year-olds in the minimal regret condition of the current study is surprising given that Weisberg and Beck (2010) reported that children as young as 7 years old experience relief. Again, methodological differences between the two studies might account for this discrepancy. In our study, participants were confronted to a monetary gambling task—a situation of decision making under risk—where decisions were based on the probabilities of winning and the possible outcomes of each wheel, which was not the case in Weisberg and Beck's study. Further investigations will be necessary to determine the effect of manipulating winning probabilities on the developmental trajectories of regret and relief in decision making.

The fact that children experienced relief after a small gain (maximal relief condition) but not after a small loss (minimal relief condition) might suggest that these groups are generally more sensitive to obtained loss. They might have difficulty in distinguishing between two outcomes that both lead to a loss and, thus, might focus more on the superior loss of the alternative gamble than on their chosen gamble. This result is consistent with the result reported by Weisberg and Beck (in press) that distinguished four types of outcome (regret after a loss, regret after a win, relief after a loss, and relief after a win), as in the current study. These authors observed that relief after an initial loss (minimal relief) was experienced later than relief after an initial win (maximal relief). Taken together, negative outcomes could more accurately reveal the development of the experience of relief in children and adolescents.

Finally, one could argue that age-related changes observed in the emotional scores in the minimal and maximal regret conditions could be due to developmental differences in partial feedback ratings. However, we note that emotional ratings on the partial feedback did not reveal any effect of age,  $F(2, 49) = 1.72$ ,  $p = .19$ , or type of outcome,  $F(1, 49) = 2.66$ ,  $p = .11$ , indicating that the three age groups were globally satisfied with having made an advantageous choice regardless of the outcome. Thus, the

developmental trend identified on the emotional complete feedback ratings cannot be attributed to partial feedback ratings.

The counterfactual nature of disappointment is debated. For instance, Guttentag and Ferrell (2008) argued that disappointment is a counterfactual emotion experienced when the outcome is worse than expected. Analyses of participants' ratings on the partial feedback condition revealed no significant difference between the experience of disappointment and the experience of elation, which is consistent with Mandel's (2003) assumption that disappointment, which is based on expectations that never materialize, is a more general emotion than regret, which is based on a comparison between different alternatives once another decision has been made. In addition, disappointment is less related to counterfactual availability than regret (Mandel, 2003). In our view, one of the key distinctions between disappointment and regret is the degree of salience of the alternative outcome. That is, unlike disappointment (associated with implicit counterfactual expectations), regret is based on a conflict between two explicit outcomes.

### "Choice" ratings

As with the emotional scores, we first conducted one-sample *t* tests for each of the four outcome conditions to determine whether the choice scores differed from zero, which would suggest that participants wanted to modify their initial choice (negative score) or wanted to maintain their initial choice (positive score) (Fig. 2B). All *p* values were corrected with a Bonferroni procedure. We then conducted a mixed-design ANOVA on the choice scores to study developmental changes.

Adults and adolescents wished to modify their choices in the minimal regret (win–win) condition,  $M = -3.16$ ,  $t(16) = -5.43$ ,  $p < .001$  for adults and  $M = -1.87$ ,  $t(16) = -4.67$ ,  $p < .005$  for adolescents, and in the maximal regret (loss–win) condition,  $M = -2.88$ ,  $t(16) = -4.55$ ,  $p < .001$  for adults and  $M = -2.63$ ,  $t(16) = -3.60$ ,  $p < .01$  for adolescents. Children wished to modify their initial choice in the maximal regret condition,  $M = -1.53$ ,  $t(18) = -3.18$ ,  $p < .05$ , but not in the minimal regret condition,  $M = -.49$ ,  $t(18) = 1.27$ . Children and adults wished to maintain their initial choices in the maximal relief (win–loss) condition,  $M = .63$ ,  $t(18) = 3.24$ ,  $p < .05$  for children and  $M = .77$ ,  $t(16) = 4.74$ ,  $p < .001$  for adults, but adolescents expressed no preference,  $M = .68$ ,  $t(16) = 1.95$ ,  $p = .07$ . Only adults reported wishing to maintain their initial choice in the minimal regret (loss–loss) condition,  $M = 1.09$ ,  $t(16) = 4.23$ ,  $p < .005$ . In this condition, children and adolescents expressed no preference about modifying their initial choice,  $M = .30$ ,  $t(18) = 1.03$  for children and  $M = .10$ ,  $t(16) = .71$  for adolescents.

The 3 (Age Group)  $\times$  4 (Type of Outcome) mixed-design ANOVA on the choice scores revealed a main effect of type of outcome,  $F(3, 150) = 36.70$ ,  $p < .001$ ,  $\eta_p^2 = .42$ , but no main effect of age group,  $F(2, 50) = 2.87$ ,  $p = .07$ . Interestingly, the interaction between age group and type of outcome was significant,  $F(6, 150) = 2.54$ ,  $p < .05$ ,  $\eta_p^2 = .09$ . Planned comparisons of the choice scores revealed that children were less willing to modify their initial choice than adolescents,  $t(34) = -2.41$ ,  $p < .01$ ,  $d = .66$ , and adults,  $t(34) = -3.00$ ,  $p < .005$ ,  $d = 1.23$ , in the minimal regret (win–win) condition. Similarly, in the maximal regret (loss–win) condition, children were less willing to modify their initial choice than adults,  $t(34) = -1.70$ ,  $p < .05$ ,  $d = .61$ . No other differences were significant.

Given that counterfactually mediated emotions rely directly on participants' choice, we considered the impact of these emotions on participants' willingness to modify their initial choice. As expected, adults wished to modify their initial choice in the conditions inducing regret but wished to maintain their initial choice in the conditions inducing relief. In contrast to adults, children and adolescents expressed no preference about modifying their choice in the condition inducing minimal relief. Even when children experienced regret, in the minimal regret (win–win) condition, they did not wish to modify their choice. One could argue that the failure to express a desire to change an initial choice in the minimal regret condition (after a high win on the unobtained outcome) could reflect a lack of understanding of the choice rating. However, children's choice scores differed from zero in the maximal relief and maximal regret conditions, suggesting that children provided different partial feedback and complete feedback ratings in these two conditions. Thus, we are confident that the children understood the instructions. In children, the lack of significant emotional experience in the minimal regret condition may arise because children do not feel that they have control over the outcome. Given that feeling responsible for the outcome is crucial to inducing regret and relief (and not frustration;



see also Weisberg & Beck, *in press*), the task was designed in such a way that the outcome results directly from participants' choice.

The dissociation between the experience of a counterfactually mediated emotion (i.e., minimal regret) and the willingness to reconsider an initial choice is observed only in the win–win condition in children. In this condition, the salience of the counterfactual alternative might be reduced because participants have already won on the selected wheel. Children seem to experience difficulty in thinking counterfactually and then expressing their wish to modify their initial choice when the obtained outcome is already good. This result may indicate a developmental dissociation between feeling and doing. Interestingly, a similar dissociation between the ability to experience emotions and the desire to shift to another choice was observed in the Iowa gambling task with children and adolescents of the same age range (Cassotti, Houdé, & Moutier, 2011).

In the maximal relief condition, adolescents did not express a willingness to maintain their initial choice, contrary to children and adults. This result is developmentally surprising and should be viewed with caution given that the variability of choice ratings was higher in this group than in children,  $F(16, 18) = 2.56, p < .05$ , and adults,  $F(16, 16) = 3.23, p < .025$ .

The results from the choice scale reveal the importance of using both emotional and choice ratings to study the precise development of counterfactually mediated emotions such as regret and relief and, to a larger extent, the development of the ability to consider these emotions through metacognitive choice evaluation to adapt to new situations.

## Conclusion

We found evidence that the ability to experience counterfactually mediated emotions continues to develop during late childhood and adolescence, consistent with the implications of the OFC on the experience of regret. In particular, children's and adolescents' subjective experiences of regret were effective but reduced compared with those of adults. Moreover, our results demonstrate that regret leads adults to reconsider their initial choice, whereas regret does not systematically lead children to reconsider their initial choice. Thus, we identified a dissociation in children between the experience of regret and the willingness to reconsider an initial choice.

The current study provides additional fuel for the current debates on the influence of complex, cognitively based emotions in decision making under risk and their specific developing role in initial choice reconsideration and inspiration for change.

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