The role of agency in regret and relief in 3- to 10-year-old children☆

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ABSTRACT

The emotions of regret and relief are mediated by the counterfactual comparison between the obtained and foregone outcomes of our decisions. Regret is strongly associated with a feeling of responsibility for a decision when the outcome might have been better. This may be contrasted with disappointment, which is experienced when the outcome occurs independently of the agent's decisions. The same contrast may be made between these emotions' positive counterparts of relief and elation. The current studies seek to make important distinctions between children's experience of regret and disappointment, and relief and elation. Children aged between 3 and 10 years ($N = 225$) chose between two gambles with different levels of risk under differing conditions of feedback and agency. There was a significant effect of agency for children aged 6 years and older following regret eliciting trials. A significant effect of agency was found only for children aged 10 years for relief trials. There was no effect of agency for elation and disappointment trials. These findings suggest that children as young as 6 are sensitive to manipulations of agency, and that responsibility for a decision is crucial for children to feel a negative emotion upon discovering that acting otherwise would have turned out better. These findings suggest a more nuanced developmental trajectory for the counterfactual emotions than was previously considered.

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1. Introduction

Counterfactual thinking, the comparison of reality with its alternatives, is a fundamental cognitive process that improves humans' capacity to learn from mistakes, is critical for judgments about moral responsibility (a free agent is someone who could have acted otherwise; Nagel, 1987), and is implicated in juridical (Catellani and Milesi, 2005) and other important decision-making processes (Smallman and Summerville, 2018). Furthermore, counterfactual thinking can mediate emotional responses to outcomes or events. Specifically, thinking about how things might have been better (an *upward* comparison) can lead to regret, and thinking about how things might have been worse (a *downward* comparison) can lead to relief. For example, having failed an exam, one might think: "If only I had studied more, I would not have failed the exam", thus experiencing regret by considering a better counterfactual outcome. Alternatively, having chosen to drive to work over

cycling, one might think: "If I had cycled to work, I would have been soaked in the rainstorm", thus experiencing relief by considering a worse counterfactual outcome.

1.1. The bi-directional relationship between counterfactual emotions and decision making

An important feature of these emotions is their bi-directional relationship with decision-making. Counterfactual emotions are considered to play a functional role in decision making (Epstude and Roese, 2008). In particular, the experience of regret is thought to result in adaptive behavior change. This functional role has been found to emerge early: A number of studies with children have shown that 6- and 7-year-olds who report experiencing regret go on to make better decisions than their same-age peers who do not report regret (McCormack et al., 2019; O'Connor et al., 2014; however, see O'Connor et al., 2015 for evidence that this behavior may generalize to other negative emotions).

Not only are these emotions key in guiding our learning and adaptive decision making, but they are also only evoked *after* a decision has been made. Both regret and relief require responsibility for the events that led to the obtained outcome rather than its counterfactual counterpart (Zeelenberg et al., 1998a). It is this important additional component of agency that distinguishes these emotions from disappointment and elation.

Personal responsibility and the notion that one *could have done otherwise* are integral to our definition of regret, and these factors differentiate it from another counterfactual emotion: disappointment. Specifically, regret is felt when the outcome of a decision turned out worse than it would have done had an alternative course of action had been taken, whereas disappointment is felt when the outcome turned out worse than it would have done had a chance event turned out differently. Conversely, relief is felt when the outcome of a decision turned out better than it would have done had an alternative course of action had been taken, whereas elation is felt when the outcome turned out better than it would have done had a chance event turned out differently. Put simply, regret and relief are experienced when we consider what might have been *had we chosen differently*, thus focusing on our agency over the action and personal responsibility for its outcome (Kasimatis and Wells, 2014; Markman et al., 1993; Mellers, 2000; Zeelenberg et al., 1998b).

Emotional responses tend to be amplified by the feeling of responsibility for the outcome. Knowing that one could have done otherwise, and a better outcome would have pertained, amplifies one's feeling of dissatisfaction with the obtained outcome (Kahneman and Miller, 1986). As such, with all other factors being equal, adults tend to experience regret more keenly than disappointment, i.e., an emotional "amplification effect" (e.g. Camille et al., 2004). Furthermore, brain activity associated with the experience of relief and regret, but not disappointment and elation, has been localized to the orbitofrontal cortex (Camille et al., 2004; Coricelli et al., 2005). The activity in the orbitofrontal cortex is selectively related to counterfactual comparisons when personal responsibility is felt for comparatively good or bad outcomes (Coricelli et al., 2005).

1.2. The development of counterfactual emotions

A coherent picture of the development of these counterfactual emotions is yet to emerge. The developmental trajectories of these emotions are still the subject of much debate (Beck, 2016; Rafetseder and Perner, 2012), and studies directly addressing their development diverge with regard to both the age at which these counterfactual emotions first emerge, and whether there is a lag between the development of regret and relief (see Beck and Riggs, 2014, for a review).

Indeed, the developmental trajectories of the supporting cognitive functions and brain regions lead to differing predictions about the emergence of counterfactual emotions. On one hand, evidence from preschool children's intuitions about free will and the ability to do otherwise (Kushnir et al., 2015), and their reasoning about counterfactual antecedents (Harris et al., 1996) suggests that children ought to have the cognitive capacities in place to experience regret and relief from as young as three years of age. In contrast, the orbitofrontal cortex is known to develop late relative to other areas involved in decision evaluation, reaching maturity during adolescence (Galvan et al., 2006; Gogtay et al., 2004).

Studies of the development of the role of counterfactual emotions in decision-making typically involve children choosing between two opaque boxes, and receiving the contents of the chosen box, for example, three stickers. Children are then shown the contents of the unchosen box, for example, eight stickers, and asked to rate how they feel. In these studies, regret is typified by children reporting a negative emotion upon discovering that the unchosen box contained a better reward than the chosen box (e.g. more stickers). Conversely, an expression of relief is typified by children reporting a positive emotion upon discovering that the outcome of the unchosen box contained a worse reward than the chosen box (e.g. fewer stickers). In these studies, it is not possible to differentiate children's regret at *having chosen* the box with the poorer outcome, from their disappointment at simply having received the box with the poorer outcome (see Rafetseder and Perner, 2014, for a similar assertion).

There is evidence to suggest a role for children's agency over their decisions in their affective responses to the actual and counterfactual outcomes. In a study by Weisberg and Beck (2012, Experiment 2), agency was manipulated between three conditions: in the *choice* condition, children chose between two opaque boxes; in the *no choice-child* condition, children rolled a colored dice that determined the box to be opened; and in the *no choice-experimenter* condition, the experimenter rolled the dice that determined the box to be opened. Even 5- to 6-year-olds were sensitive to their responsibility for the outcomes: as the level of responsibility for the outcome increased, children were more likely to report experiencing positive and negative emotions after learning about worse or better counterfactual outcomes respectively (see also, O'Connor et al., 2015, for similar findings with 6- and 7-years-olds). Nevertheless, even in the *choice* condition, children were not truly

responsible for the outcome of their choice since they chose from a position of ignorance, blindly selecting one box with no idea about its possible contents. Further, since even the youngest children in this study differentiated between the *choice* and *no choice* conditions, it is not yet understood at what age this sensitivity to one's own responsibility for outcomes first emerges. Finally, it is not clear whether children simply disengage from all alternative outcomes when they did not make the choice, or whether they might still experience disappointment when an outcome over which they did not have agency turned out worse than they expected.

Developmental studies of counterfactual emotions have differed in the approach to probing children's emotions. The first approach is to employ a within-trial design, whereby children rate their emotions twice within each trial. The child is first shown the contents of their chosen box, and they rate how they feel about the outcome. The contents of the unchosen box are then revealed, and the child is asked to rate once again how they feel (either on the same scale, or by stating whether they felt better, worse or the same). Studies using the within-trial design have found evidence for early emergence of counterfactual emotions in children as young as five or six years (Burns et al., 2012; O'Connor et al., 2012; Van Duijvenvoorde et al., 2014; Weisberg and Beck, 2012).

However, the within-trial approach has been criticized, as it is thought that the dual-questioning technique may prompt young children to change their responses, thus creating false-positive indications of regret and relief in the youngest children (see Rafetseder and Perner, 2012, Experiments 1 and 3). In contrast, when partial feedback (i.e. only the contents of the chosen box are revealed) and complete feedback (i.e. the contents of both the chosen box and the unchosen box are revealed) are given on separate trials, and emotion ratings made only once at the end of each trial counterfactual emotions are not consistently seen until later, between 8 and 14 years of age (McCormack et al., 2016; Rafetseder and Perner, 2012, Experiment 3).

A further criticism of the standard developmental paradigm is that the decisions that children make are arbitrary, they choose 'blindly' between two opaque boxes without knowing the likelihood of being rewarded for their choice. The arbitrary nature of the choice may have attenuated children's sense of responsibility for the outcomes, and in turn their experience of regret. A recent study has sought to address this criticism by having children make decisions from a position of knowledge, rather than of ignorance (McCormack et al., 2016). In a paradigm adapted from the Wheels of Fortune Task, commonly used in the adult literature (Camille et al., 2004; Coricelli et al., 2005; Mellers et al., 1999), 6- to 9-year-old children made informed choices between 'safe' and 'risky' boxes, each with two potential outcomes that were known in advance. Children's emotion ratings were compared between a partial feedback condition, where they learned the outcome of their chosen gamble only, and a complete feedback condition, where they learned the outcomes of both gambles. The authors found that when a within-trial analysis was conducted, 6- to 9-year-olds reported that they felt "sadder" more often upon discovering that the outcome of the unchosen box was better than their obtained outcome, than upon discovering that the outcome of the unchosen box was worse than their obtained outcome. (When comparing between trials, this effect was only marginal for the 6- to 7-year-olds.)

McCormack et al. (2016) study thus presents a methodological improvement on earlier studies. However, due to the limited age-range, it is still not known when children first experience regret and relief, nor whether responses to the outcomes of risky decisions are also sensitive to the child's responsibility for the initial choice. Further, the design of this study was such that emotional responses were compared between 'regret' trials and 'elation' trials (i.e. children had received the better of the two options on their chosen gamble, so made a downward comparison when they had partial feedback, but an upward comparison when they had complete feedback), and between 'relief' and 'disappointment' trials. It seems unsurprising that children would feel worse when making an upward comparison than when making a downward comparison, irrespective of the personal responsibility for the choice, so this method of analysis does not help us to determine whether children's emotional responses were tied to their responsibility for the outcomes.

1.3. The current study

In the current study, children between the ages of 3 and 10 years completed a Wheels of Fortune task in which they chose between two gambles of differing risk (see Fig. 1). Each gamble has two possible outcome values: differing numbers of sticker rewards. The rewards available were represented with cardboard tokens prior to the choice being made. Thus, unlike most previous developmental studies of counterfactual emotions, children's choices were not arbitrary and children were in a position to feel genuinely responsible for the outcome they obtained.

Furthermore, by varying the information that the child received after making their choice, a distinction between development of regret and mere disappointment, and conversely relief and mere elation, could be established. On Partial Feedback trials, only the outcome of the chosen gamble was revealed. On Complete Feedback trials, both the outcome of the chosen gamble and the unchosen gamble were revealed. Thus a distinction could be made between emotional responses to alternatives that were missed by chance (partial feedback), and those that were missed by choice (complete feedback). Finally, by varying the agent of choice, the ontogeny of the role that responsibility for the choice plays in the experience of relief and regret, and also disappointment and elation can be determined for the first time.

The current study brings coherence to this hitherto divergent literature by bringing together the methodological improvements that had previously been applied piecemeal across different studies. First, a broad age range was tested with the same task so that subtle age-related changes in both regret and relief could be mapped out. Second, children made informed choices that could be more or less risky, and so were in a position to genuinely admonish their own decisions
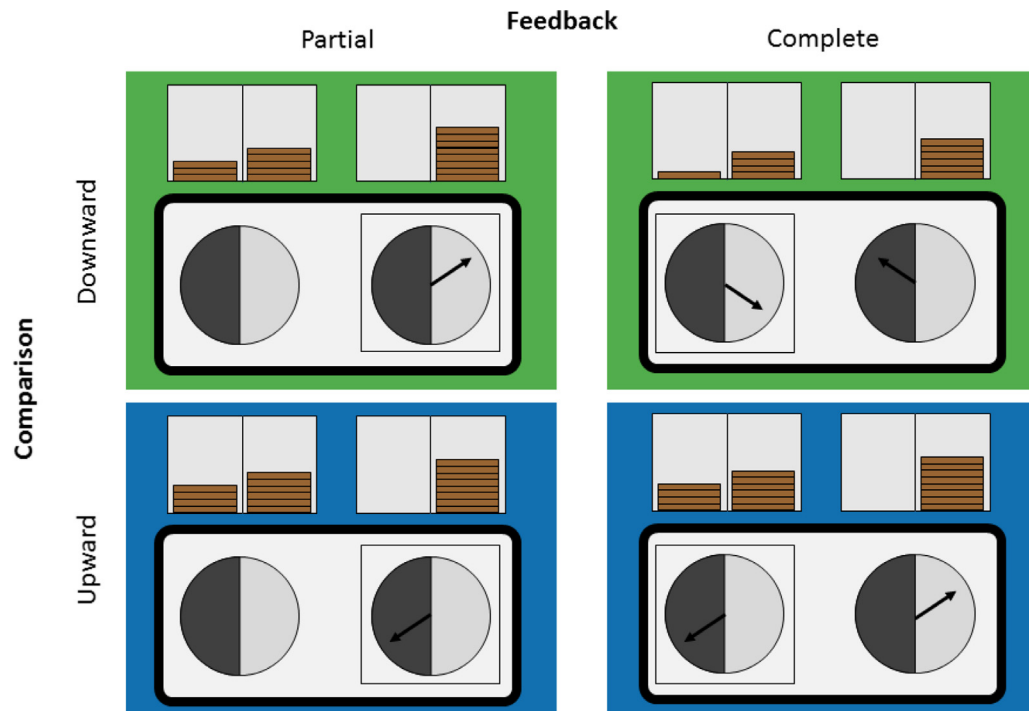
Fig. 1. Four conditions of the Wheels of Fortune task. On each trial, potential winnings were represented with cardboard tokens in boxes aligned with bisected wheels displayed on a tablet. On child agency trials, children chose by touching one of the wheels on the tablet screen. A black box appeared around the chosen wheel. On partial feedback trials (left panel), the outcome of the chosen wheel was revealed. This gives the conditions for elation when a downward comparison is made between the obtained outcome and the unobtained outcome (the other outcome on the same wheel, upper panel), or disappointment when an upward comparison is made (lower panel). On complete feedback trials (right panel), the outcomes of both the chosen and unchosen wheels were revealed. This gives the conditions for relief when a downward comparison is made between the obtained outcome and the unobtained outcome (the outcome of the other wheel), or regret when an upward comparison is made. Note that on computer agency trials (not shown), a further wheel was displayed between the two choice wheels, and an arrow indicated which wheel the computer had chosen. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

when they learned that the outcome might have been better had they acted differently. Third, the paradigm included varying levels of feedback and agency, allowing a strong distinction to be made between conditions that may lead to regret and relief, and those that may only lead to disappointment and elation.

2. Method

2.1. Participants

Participants were 225 3- to 10-year-old children (109 boys; mean age = 5;5 years; range = 3;0 years to 10;11) of European ethnicity and middle economic status. Participants were recruited in schools and kindergarten in CITY, COUNTRY. Parents signed an informed consent to allow their children to participate. Each child was tested in a quiet room in the kindergarten or school. Test sessions lasted approximately 20 min. The study was approved by the ethical committee of the University of Trento, Italy. The 3-year-olds failed to use the rating scale in an appropriate manner (they did not distinguish between good and bad outcomes), so were excluded from the analyses resulting in a final sample of 205 participants.

2.2. Stimuli and materials

On each trial, children were presented with two transparent plastic boxes, each divided into two sections. The potential outcomes (quantity of brightly colored stickers) of the two gambles were represented by stacks of cardboard tokens in the sections of the transparent boxes. For example, the left box might have contained three tokens in the left section and five tokens in the right section, while the right box might have contained zero tokens in the left side and eight tokens in the right side. Note that in this example, the left box would represent a 'safe' gamble and the right box would represent a 'risky' gamble. A tablet computer in front of the boxes displayed two equally bisected circles, with each circle aligning with one of the boxes, and the two halves of the circles aligning with the two sections of the boxes (see Fig. 1). In the child agency condition, children chose between the two gambles by touching one of the wheels on the tablet. In the computer
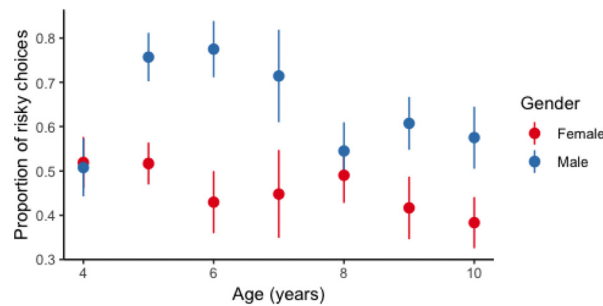
Fig. 2. Proportion of risky choices by age and gender. Female participants were more risk averse than male participants and risk taking decreased with age.

agency condition, a third, smaller wheel appeared between the two gamble wheels, and an arrow spun and stopped to determine which wheel the computer had chosen. The choice was marked by a square appearing around the chosen circle. The outcome of each gamble was determined by a spinning arrow that moved around the circle and stopped, pointing to either the left side or the right side of its corresponding box. Children rated their emotions on a five-point pictorial Likert scale, depicting five cartoon faces ranging from 'very sad' to 'very happy'. Children selected two avatars from a selection of eight small toys. Avatars were placed next to the gamble outcomes to increase their salience. See Supplementary Materials for photographs of task materials.

2.3. Procedure

First, all children were trained on the emotion evaluation scale. Children were asked to point to the "very happy", "happy", "not happy or sad", "sad" and "very sad" faces in a random order. Children who responded incorrectly were given an explanation of the faces and what they represent by the experimenter and then asked to point to each face again. No child failed to respond correctly after the explanation. Once it was established that children could use the emotion evaluation scale accurately, the child was asked to pick out two avatars from a selection of small toys.

Children then completed four blocks of the gambling task, each with one practice trial and four test trials (16 test trials total). In the first two blocks, the child was the agent of choice: Children chose one of the two gambles, and received the outcome of their chosen gamble. In the second two blocks the computer was the agent of choice: The gamble was chosen for the child by the computer, and the child received the outcome of the chosen gamble. Within each agency condition, in the first block, children received "partial" feedback: They saw the outcome of the chosen gamble only. In the second block, children received "complete" feedback: They saw the outcomes of both the chosen gamble and the unchosen gamble. The trials were administered in a pre-specified order that varied between blocks (see Supplementary Materials). The trials can be described in terms of whether the unobtained outcome was better, an *upward* comparison, or worse than the obtained outcome, a *downward* comparison. As is typical for this type of task (Camille et al., 2004; Bault et al., 2016), the outcome referred to as the unobtained outcome differed between the two types of feedback. On partial feedback trials, the unobtained outcome was the other outcome on the chosen wheel, the outcome missed by chance. On complete feedback trials, the unobtained outcome was the outcome on the unchosen wheel, the outcome missed by choice (see Fig. 1). To ensure that children attended the relevant information on each trial, the obtained and unobtained outcomes were marked with two avatars when the outcomes were revealed.

3. Results

3.1. Risk preferences

On each trial, children could choose a risky or safe option, and their choice affected both the actual and counterfactual outcomes for the trial. Preliminary analyses suggested that children's risk preference varied with age and gender (see Fig. 2). Female participants chose the risky option less often (46%) than male participants (64%) and risk taking decreased with age. Trial-wise choice (risky or safe) was thus included as a control variable in analyses of children's emotion ratings.

Table 1
Model estimates for models predicting children's emotion ratings in upward and downward comparison trials.

Predictor	Upward comparison (disappointment and regret)	Downward comparison (elation and relief)
(Intercept)	0.16 [0.05 – 0.28]**	1.22 [1.14 – 1.29] ***
Feedback (−1 = partial, 1 = complete)	0.10 [0.05 – 0.15] ***	0.03 [−0.01 – 0.06]
Agent (−1 = computer, 1 = child)	−0.17 [−0.22 – −0.11] ***	0.10 [0.05 – 0.14] ***
Age (years, mean centered)	−0.17 [−0.22 – −0.12] ***	0.09 [0.05 – 0.12] ***
Choice (−1 = safe, 1 = risky)	−0.34 [−0.43 – −0.24] ***	0.19 [0.11 – 0.26] ***
Feedback:Agency	−0.19 [−0.24 – −0.14] ***	0.03 [−0.01 – 0.07]
Feedback:Age	0.00 [−0.03 – 0.02]	0.00 [−0.02 – 0.02]
Agency:Age	−0.03 [−0.06 – −0.01]*	0.00 [−0.02 – 0.02]
Feedback:Agency:Age	−0.05 [−0.08 – −0.03] ***	0.03 [0.01 – 0.05]**

95% confidence intervals in square parentheses *$p < .05$, **$p < .01$, ***$p < .001$.
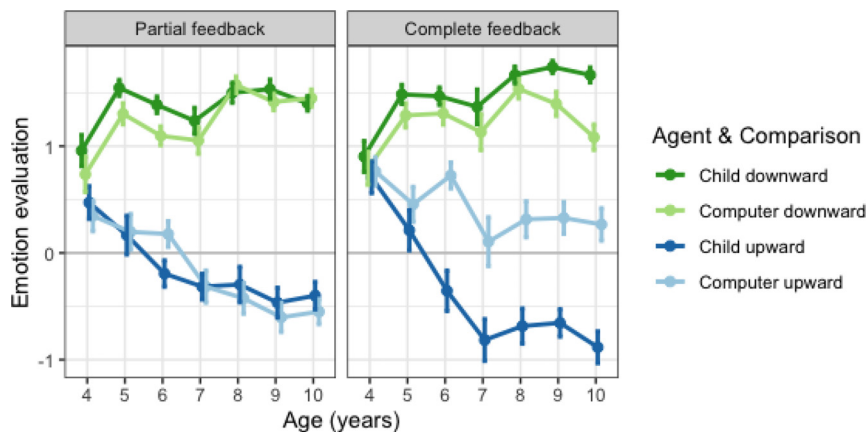
Fig. 3. Mean (SE) emotion rating by age, feedback, agent and direction of comparison.

3.2. Emotion ratings

To investigate regret and disappointment, and relief and elation, two separate linear mixed-effects models were conducted for trials in which an upward or a downward comparison was made respectively. Each model had *emotion evaluation* as the dependent variable (coded from −2 = 'very sad' to +2 = 'very happy'), *feedback* (−1 = partial and 1 = complete), *agent* (−1 = computer and 1 = child), and *age* (mean centered) as predictors, these predictors were entered in a full factorial design including all interactions. *Choice* (−1 = safe and 1 = risky) was included as a trial-level control variable since risky choices were found to decrease with age and different choices led to different trial outcomes. Subject was included as a random effect, with random slopes for *feedback, agent*, and their interaction. Model estimates can be found in Table 1. Despite male participants being more likely to choose the risky option than female participants, including gender in the model did not improve model fits so is not included in the following analyses (downward: $\chi^2 = 2.86$, $p = .09$; upward: $\chi^2 = 1.18$, $p = .28$).

3.2.1. Upward comparison: disappointment and regret

In upward comparison trials in which the unobtained outcome was better than the obtained outcome, there were significant main effects of *age, feedback, agency, and choice* (see Table 1 for estimates of these fixed effects). Overall, children's emotion ratings became more negative with age, children felt better when they received complete feedback than when they received partial feedback, and children felt worse when they made the choice than when the computer made the choice. Further, children felt worse when they made the risky choice, this would be expected since children obtained fewer tokens when they made the risky choice rather than the safe choice on upward comparison trials.

These main effects were qualified by two significant two-way interactions, and one three-way interaction. There was a two-way interaction between *age* and *agent*. Observation of the means (see Fig. 3) revealed that the effect of *agent* was greater for older children than for younger children. There was also an interaction between *feedback* and *agent*. Post-hoc tests

with Holm–Bonferroni adjusted p-values revealed that when children received complete feedback, they felt significantly worse when they had made the choice themselves than when the computer had made the choice, $t(204) = -8.32$, $p < .001$. In contrast, when they received partial feedback, the agent of choice did not affect children's emotion evaluations, $t(204) = 0.30$, $p > .99$.

It is interesting to note that we did not find the classic amplification effect whereby regret is felt more keenly than disappointment. Breaking the results down by agent revealed that when the child was the agent of choice, they did not feel worse when they received complete feedback than when they received partial feedback, $t(204) = 2.17$, adjusted $p = .09$. In contrast, when the computer was the agent of choice, children felt better when they received complete feedback than when they received partial feedback, $t(204) = -8.68$, adjusted $p < .001$. The final two-way interaction between *age* and *feedback* was not significant.

Finally, there was a significant three-way interaction between *age, agent* and *feedback*. Post-hoc tests with Holm-Bonferroni adjusted p-values and age stratified by year revealed that there was no effect of agency in the partial feedback condition for any age group (all adjusted $ps > 0.5$), but there was a negative effect of agency in the complete feedback condition for children aged 6 years and older (adjusted $ps < 0.01$) with the exception of 7-year-olds for whom there was a marginal effect (adjusted $p = .08$). This finding suggests that prior to the age of six years, children's emotional responses to foregone alternatives were not associated with their responsibility for the outcomes.

A simpler metric for the experience of regret is to determine the age at which children first report feeling sad after learning that their obtained outcome was worse than one they might have had, had they acted differently. For this analysis we looked only at complete feedback, child agent trials (those in which the emotion of regret should be elicited; Camille et al., 2004). Children's emotion evaluations were entered into one-sample t-tests to determine whether they were less than 0 ('neither happy nor sad'), see Fig. 2. Four- and 5-year-olds did not report feeling sad when their outcome was worse on complete or partial trials ($ps > 0.1$). Children aged 7 older ($ps_{\text{one-sided}} < 0.005$, marginal effect for 6-year-olds $p_{\text{one-sided}} = 0.09$) reported feeling sad when their outcome was worse than one they might have had, had they acted differently (complete trials). A similar analysis can be conducted for the experience of disappointment by looking only at partial feedback, child agent trials. Again, 7-, 9- and 10-year-olds, ($ps_{\text{one-sided}} < 0.05$) reported feeling bad when their outcome was worse than one they might have had by chance, and 6- and 8-year-olds felt marginally worse ($p_{\text{one-sided}} = 0.08$ and 0.07 respectively).

3.2.2. Downward comparison: elation and relief

For the downward comparison trials, in which the unobtained outcome was worse than the obtained outcome, there were main effects of *age, agent*, and *choice* and a three-way interaction between *age, agent* and *feedback* (see Table 1 for estimates of the fixed effects). Overall in downward comparison trials, older children reported more positive emotion than younger children, and children reported more positive emotion when they had made the choice than when the computer had made the choice. Children felt better after making risky choices than safe choices, this would be expected since they obtained more tokens when they made the risky choice rather than the safe choice on downward comparison trials. Observation of the means (see Fig. 2) suggests that the three-way interaction between *age, agent* and *feedback* can be explained by the oldest children's elevated positive emotion on complete feedback trials when they had made the choice. Indeed, post-hoc tests with Holm-Bonferroni adjusted p-values and age stratified by year revealed that the effect of agency did not hold in the partial feedback condition for any age group (all adjusted $ps > 0.1$), but did hold in the complete feedback condition for 10-year-olds (adjusted $p = .006$). These findings suggest that relief and elation are not easily teased apart during childhood. However, this could have been due to ceiling effects since 49% of responses were at the highest value across the two downward comparison conditions.

3.3. Effects of emotion on choice adaptation

In the analyses presented thus far, we have demonstrated that from around the age of 6 years, children become sensitive to their responsibility for decisions, and this pays an important role in their experience of negative emotions upon learning that another choice could have led to a better outcome. Previous research has also shown that children who experience these negative emotions are more likely to change their choice when faced with the same decision again (McCormack et al., 2019; O'Connor et al., 2014). In a logistic mixed-effects model restricted to the trials in which children had agency over their decisions, we tentatively examined the effects of children's emotion ratings on their choice adaptation in the next trial $(t + 1)$. The model had *choice shift $(t + 1)$* as the binary dependent variable (0 = repeat [safe-safe or risky-risky], 1 = shift [safe-risky or risky-safe]), and *emotion rating* (5-point scale, mean-centered within participant), *choice (t)* (-1 = safe and 1 = risky), *feedback* (-1 = partial, 1 = complete), and *age* (mean centered) as predictors. The predictors were entered in a full-factorial design including all interactions. Subject was included as a random effect, with random slopes for *emotion rating, choice (t), feedback* and their interactions (random effects correlation parameters were fixed to zero to reduce model complexity, Bates et al., 2015). Model estimates (odds ratios) can be found in Table 2.

Older children were more likely to shift their choices in trial $t + 1$ than younger children, but this effect did not interact with choice at t suggesting that older children both switched from risky to safe and from safe to risky choices. Younger children were more idiosyncratic in their choices, being more likely to repeat risky or safe choices on the next trial. Emotion rating interacted with age, and examination of choice shifts among the older, middle, and younger children in the sample (Fig. 4) reveals that older children are more likely to shift response after negative emotions. At all ages, after experiencing

Table 2

Model estimates for model predicting shifts in children's choices at trial $t + 1$.

Predictor	Odds ratio [95% confidence intervals]
(Intercept)	0.63 [0.53 – 0.75] ***
Emotion rating at t (individual mean centered)	0.92 [0.83 – 1.03]
Age (years, mean centered)	1.15 [1.06 – 1.25]**
Choice at t (−1 = safe, 1 = risky)	0.97 [0.85 – 1.11]
Feedback at t (−1 = partial, 1 = complete)	0.94 [0.83 – 1.07]
Emotion rating:Age	0.90 [0.85 – 0.95] ***
Emotion rating:Choice	0.98 [0.88 – 1.09]
Age:Choice	1.03 [0.97 – 1.10]
Emotion rating:Feedback	1.07 [0.96 – 1.20]
Age:Feedback	1.06 [1.00 – 1.12]
Choice:Feedback	1.23 [1.09 – 1.40]**
Emotion rating:Age:Choice	1.04 [0.98 – 1.09]
Emotion rating:Age:Feedback	1.01 [0.96 – 1.07]
Emotion rating:Choice:Feedback	1.06 [0.95 – 1.19]
Age:Choice:Feedback	1.06 [0.99 – 1.12]
Emotion rating:Age:Choice:Feedback	1.01 [0.95 – 1.06]

$^*p < .05$, $^{**}p < .01$, $^{***}p < .001$.
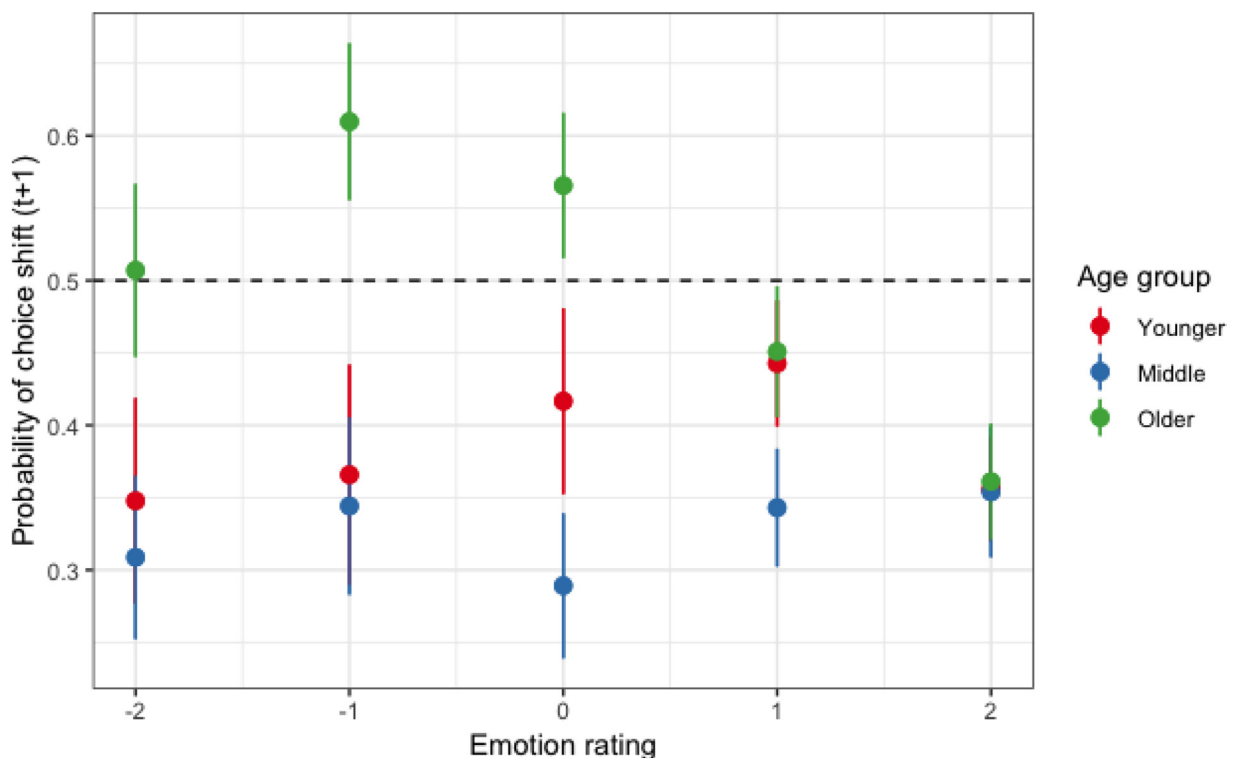
Fig. 4. Mean (SE) probability of a choice shift by emotion rating and age.

positive emotions, children were more likely to repeat their choice than to switch. This effect was not qualified by choice at trial t nor by feedback. Finally, there was a positive interaction between feedback and choice suggesting that children were more likely to switch after risky choices and stick with safe choices when they received complete feedback than when they received partial feedback.

4. Discussion

In this study, children aged between 3 and 10 years completed a gambling task in which they, or a computer chose between 'wheels of fortune' of differing risk. Children were either shown the outcomes of their chosen wheel only (partial feedback), or the outcome of both their chosen wheel and the unchosen wheel (complete feedback). In both cases, children could compare their obtained outcome to an unobtained outcome, either the alternative outcome on the chosen wheel, or the outcome that they would have had if the other wheel had been chosen. We found that when making 'upward compar-

isons', i.e. the unobtained outcome was better than the obtained outcome, children began to report feeling bad from around 6 years of age, irrespective of whether they were comparing their outcome to one they missed by chance (partial feedback) or by choice (complete feedback). This suggests that at least disappointment and possibly also regret emerge at around 6 years of age. This replicates a number of findings from the developmental literature (Burns et al., 2012; O'Connor et al., 2012; Van Duijvenvoorde et al., 2014; Weisberg and Beck, 2012).

Interestingly, the magnitude of the reported negative emotion did not differ between partial and complete trials. This was unexpected given that adults show an amplification effect, whereby outcomes missed by choice have a greater bearing on emotional responses than those missed by chance (Camille et al., 2004; Kahneman and Miller, 1986). Indeed, such an amplification effect has been considered a strict test for the existence of regret, since it differentiates regret from a mere contrast effect caused by looking at something better than one's own outcome (Rafetseder and Perner, 2012). This strict test for regret was failed by the children in this study. This finding corresponds with other studies that have not found evidence for regret in children younger than 9 to 11 years old (Rafetseder and Perner, 2012, Experiment 3).

While this may previously have been interpreted as a lack of evidence for the existence of regret in children before the age of 10 years, examination of the effects of manipulating the agent of choice suggests otherwise. The interaction between *Feedback* and *Agent* after the age of 6 suggests that children did in fact process the complete feedback differently to the partial feedback, and in exactly the direction one would expect if they experienced genuine regret (i.e. their responsibility for the action was integral to the negative emotional experience). Children's emotion ratings after partial feedback was insensitive to the agent of choice, suggesting that, in this condition, their negative emotional responses were merely due to contrast effects, or to the difference between the expected value of the outcome and its actual value (i.e. disappointment). However, after complete feedback, children felt bad when the other wheel was better than their own when they had made the choice, but were insensitive to the outcome of the other wheel when the computer had made the choice. This sensitivity to the agent of choice suggests that children's negative emotional responses were true expressions of regret. This finding extends that of Weisberg and Beck (2012, Experiment 2) by showing that children's experience of regret, but not disappointment is sensitive to the agent of choice. Thus the key finding of this research is that right from their emergence at age 6, children's experience of regret was separable from their experience of disappointment by its sensitivity to the agent of the decision.

Evidence that agency may play some role in children's positive emotional responses comes from the finding that 10-year-olds felt better after learning that an alternative outcome could have been worse when they made the choice themselves, than when the computer made the choice for them. One of the major limitations of this study was the presence of a ceiling effect in the downward comparison conditions, making it difficult to interpret the lack of effect of agency for younger children. Previous research has overcome ceiling (or floor) effects when by having children rate how their emotions changed (whether they feel better, worse or the same) after learning the alternative outcome using a within-trial design (O'Connor et al., 2012; Weisberg and Beck, 2012). This allows children to say that they feel better even if they had already rated their emotions at the top or bottom of the scale. However, such comparative ratings are impossible with the more stringent between-trial design.

Children became more risk averse with age. They were also more likely to change their choice strategy (from safe to risky, or from risky to safe) after reporting negative emotions, and this tendency increased with age. However, this effect did not interact with feedback. This suggests that, contrary to predictions based on the functional theory of regret, children do not shift more after complete feedback than after partial feedback (see O'Connor et al., 2015 for similar findings). This more nuanced integration of agency and outcomes to drive adaptive may emerge later in childhood or adolescence.

In conclusion, the findings of this study bring coherence to a previously divergent set of findings from the developmental literature, by demonstrating that both regret and disappointment emerge at around age 6, but that they cannot be differentiated by their magnitude in a between-trial design until later in childhood. Instead, responsibility for the decision, another key distinguishing feature of these emotions, must be manipulated to distinguish young children's regret from their disappointment.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jebo.2020.03.029.

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