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Conditional Reasoning and Emotional Experience: A Review of the Development of Counterfactual Thinking

Abstract. What do human beings use conditional reasoning for? A psychological consequence of counterfactual conditional reasoning is emotional experience, in particular, regret and relief. Adults' thoughts about what might have been influence their evaluations of reality. We discuss recent psychological experiments that chart the relationship between children's ability to engage in conditional reasoning and their experience of counterfactual emotions. Relative to conditional reasoning, counterfactual emotions are late developing. This suggests that children need not only competence in conditional reasoning, but also to engage in this thinking spontaneously. Developments in domain general cognitive processing (the executive functions) allow children to develop from conditional reasoning to reasoning with counterfactual content and, eventually, to experiencing counterfactual emotions.

Keywords: Developmental psychology, Cognition, Counterfactuals, Regret, Emotion.

1. Introduction

Imagine a scenario where you fail an exam. You may well find yourself thinking about the situation, for example, 'Now I will have to take a resit'. But adult human beings are very likely to engage in a type of conditional thinking, 'If I hadn't gone out the night before, then I would have passed.' These conditionals have counterfactual content: people speculate about alternative possible worlds, that could have happened, but did not. In this paper, we start from the premise that one of the most important ways in which people use their conditional reasoning is to speculate about these counterfactual worlds (See also Edgington [12] for discussion of why counterfactuals are important). These speculations result in counterfactual emotions: the feelings of regret and relief that enrich our experience of reality and help us learn from our mistakes (Roese [33]). We explore children's

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developing abilities to reason with conditionals, with counterfactual conditionals, and to experience counterfactual emotions. Because development offers intriguing dissociations in abilities, it gives us unique insight in to the relations between these abilities which are often obscured by looking only at fully competent adults.

2. Early Conditional Reasoning

From a relatively young age children are apparently able to handle some conditionals. For example, from as young as three if children are asked to speculate about possible future consequences of events they give the appropriate answer. In one study Robinson and Beck [32] showed children a simple apparatus where a car started in the middle of a straight road. It could drive from the middle to one of two garages. Once the car had driven to one garage children were asked 'What if next time he drives the other way, where will he be?' Almost all of the sample of 3 and 4 year old children answered this future hypothetical question correctly, indicating the other garage.

Despite this early competence, children are rather severely affected by the content of the conditional they are asked to reason about. In this paper we focus on a particular type of content, where children have to reason about things they know to be false. In the psychology literature, the term counterfactual reasoning is typically reserved for these situations: i.e., events where the individual must put aside what is known to be true and speculate about a false possibility as if it were true. Events in the future (for example) which are counter to the current state but cannot yet be known to be true or false are typically called hypotheticals, not counterfactuals.

Several studies have asked children to use their conditional reasoning skills to speculate about counterfactual worlds. There is some dispute about the age at which children can succeed on these tasks. Much research has focussed on changes at around 3–4 years. In the first study of children's counterfactual conditional reasoning, Harris et al. [20] told children a simple story: Teddy used a paintbrush to paint a white floor red. They asked, 'If Teddy hadn't painted the floor with his brush would the floor be clean now?' Harris et al. found that even 3-year-olds could answer this question appropriately ('yes') as well as understanding that the outcome would not be changed if they were asked 'If Teddy had painted the floor with his fingers instead, would the floor be clean now?' ('no').

German and Nichols [15] used longer narratives with four events in each story. In one story Mrs. Rosy was planting a flower. She calls her husband to

see, who opens the kitchen door allowing the dog to escape. The dog tramples on the flower. Finally, we learn that Mrs Rosy is sad. The 3- and 4-year-olds that German and Nichols questioned found it easier (and relatively easy) to answer counterfactual conditional questions about a recent event in the story, 'What if the dog hadn't squashed the flower, would Mrs. Rosy be happy or sad?' than questions that required a counterfactual change at an earlier point. For example, 'What if Mrs. Rosy hadn't called her husband, would Mrs. Rosy be happy or sad?' and 'What if the dog hadn't escaped from the house, would Mrs. Rosy be happy or sad?'

Some authors suggest that the ability to do conditional reasoning with counterfactual content emerges slightly later at around 4 years. In Riggs et al. [31] one story involved a firefighter who is at home in bed. He rushes to attend to a fire at the Post Office. Only children over 4 could correctly answer the question 'If there had been no fire, where would Peter be?' ('in bed').

Beck et al. [5] attempted to reconcile the discrepancy between claims that counterfactual conditional reasoning developed at 3 or not until 4 years of age. In line with Perner [26] they reasoned that children might be able to answer some of the questions using general knowledge, rather than considering a counterfactual. For example, imagine asking the recent event question from the German and Nichols [15] study, 'What if the dog hadn't squashed the flower, would Mrs. Rosy be happy or sad?', without the original story. If forced to guess they would likely say that Mrs Rosy would be happy (the correct answer). This general knowledge route to the answer was not available for the questions that referred to earlier events in the story, nor in Riggs et al.'s narratives. Beck et al. [5] contrasted stories where the child could and could not give the answer through general knowledge and they included questions about recent and early events in the story. Surprisingly, they did not find support for either German and Nichols' recency hypothesis nor the general knowledge account. In fact, their failure to replicate German and Nichols' finding served only to further entrench the problem of whether counterfactual conditional reasoning is easy or difficult for 3- and 4-year-olds. However, for our purposes here the exact age is irrelevant. More importantly conditional reasoning with counterfactual content is more difficult than that with factual or unfamiliar content. Yet, it appears to be within the competence of 4-year-olds (although see Rafetseder et al. [28], below).

Researchers have used individual differences measures to investigate why counterfactual content makes conditional reasoning difficult. Beck et al. [4] tested around 100 3- to 4-year-olds on counterfactual conditional tasks, counterfactual syllogistic reasoning tasks, and measures of domain general

cognitive processes: executive functions. The executive functions are processes that allow us to organise our thoughts and behaviour and include inhibitory control (the ability to suppress information that is irrelevant to a task goal) and working memory (the ability to keep information in mind relevant to a task goal), but also planning and attention. Executive functions allow flexible thinking and allow us to pursue complex goals. These processes show substantial change during early childhood and have been implicated in various high level cognitive abilities (such as social cognition, Carlson and Moses [9]). The strategy employed in this individual differences battery study is to test the same children on specific (counterfactual) and general (executive) measures and show statistically whether performance on different measures are related. A measure of verbal intelligence was also included and statistically controlled for to show that any relationship between performance on different tasks resulted from something interesting about the cognitive processes they shared, rather than just indicating that 'clever' children are good at all tasks. Beck et al. found that the measures of inhibition—for example, having to say black to a white square, and white to a black one, was predictive of how good children were at the counterfactual tasks. From this, they argued that being able to resist responding impulsively with what you know to be true was likely to be a significant part of what made conditional reasoning with counterfactual content difficult for young children. Beck et al. [3] also showed that if efforts were made to reduce the inhibitory demands, reasoning with counterfactuals became easier for 3- to 5-year-olds.

More recently, Rafetseder et al. [28] have argued that much of the evidence that children are reasoning counterfactually at around 4 years of age actually represents basic conditional reasoning (not true counterfactual thought), claiming thatcounterfactual conditional reasoning develops much later. This is further discussed in Leahy et al. [22]. This is an important challenge to the literature's preoccupation with 3- and 4-year-olds and they have convincing evidence that young children are limited in how they relate counterfactual and real worlds (see also Beck et al. [6]). Rafetseder et al. [30] suggest that true counterfactual thinking that creates a closest possible world (see Lewis [23]) is not seen until children are around 12 years old. They used a neat task, based on Harris et al. [20] in which there was double determination of an outcome. For example, Susi and Max walk across the floor wearing muddy shoes and make it dirty. When asked what would have happened if Susi had taken her shoes off, younger children (up to 10 in this sample) claimed the floor would be clean. Apparently, they ignored Max's muddy shoes.

Other authors (see e.g. Beck et al. [6]) have also argued that simply being able to reason conditionally with counterfactual content does not mark full adult-like counterfactual thinking. However, they emphasise developments in mid-childhood, substantially younger than those identified by Rafetseder and colleagues as evidence of counterfactual thought. Both groups agree, though, that true counterfactual thinking has a protracted development, but more research is needed to fully map it.

3. Counterfactual Emotions

Children's competence in being able to reason with counterfactual conditionals is only part of the story. Being able to speculate about counterfactuals is likely to be important for understanding causality (see Frosch et al. [13]) and for reasoning scientifically, but counterfactual thinking in everyday life has another important function. Being able to think counterfactually about 'what if...' different things had happened underpins the experience of a particular set of emotions. The most commonly researched counterfactual emotion is regret, although there is some research on its positive counterpart relief (see e.g. Sweeney and Vohs [34]). There are also other counterfactual emotions such as guilt and shame but as these involve the additional complications of the social world, and have received less attention from developmental researchers concerned with counterfactuals we will not discuss them further here.

Counterfactual emotions are the result of a comparison of what is known to be true with what could have happened instead. For example, while eating at a restaurant, I may deliberate over several dishes and finally decide to order the fish. When it arrives it is not very enjoyable and I wish that I had ordered the beef instead. Thus, I am comparing the real world in which I ordered the fish (resulting in a negative experience) with a counterfactual world in which 'If I had chosen the beef, I would have enjoyed my meal much more.' I feel worse about my unappetising fish dish because I could have ordered the beef, compared to a world in which fish was the only thing on the menu. Although counterfactual emotions are common place for adults, they appear to develop rather late in children. In what follows we summarise what is known about children's counterfactual emotion development and speculate about what this tells us about the deployment of conditional reasoning in sophisticated human thought.

The very first study investigating children's experience of regret was published by Amsel and Smalley [1]. They tested adults and 3- to 5-year-olds.

Participants played a card game with the experimenter where they turned over one of two cards. On critical trials the card they turned over tied against the experimenter's card, but the other card would either have either won or lost against his card. Adults' judgments of how they felt about the actual outcome (tying) was influenced by the counterfactual alternative, i.e., they were less happy when they found out the other card would have won, than when they found out it would have lost. The 3- to 5-year-olds were not affected by the counterfactual outcome. They were equally happy about the real outcome when the other card would have won or lost. However, children's conditional reasoning about the counterfactual world was good. When asked how they would have felt if they had chosen the other card when it would have won, children reported that they would have felt happier.

While Amsel and Smalley showed that children's counterfactual conditional reasoning did not appear to result in the inevitable counterfactual emotions that adults experience, the study did not show when these emotions do in fact emerge. We addressed this question (Weisberg and Beck [36]) testing older children and also simplifying the game to give children the best chance possible to experience (and demonstrate) counterfactual emotions. In our game, children were presented with two boxes. They chose one of them, which they were given to open and told they could keep the contents. The chosen box contained two or three stickers (n.b. we used sleight of hand to fix the outcomes of the trials). Children rated their feeling about their winnings on a five point scale made of sad to happy faces. Having made this initial rating, children were shown the counterfactual outcome, that is, what they could have won if they had chosen the other box. On regret trials the unchosen box contained many more stickers (8) whereas on relief trials it was empty. After they were shown the contents of the unchosen box, children re-rated their feeling about the actual outcome. Children in a sample of 5- and 6-year-olds rated themselves as less happy when they discovered that if they had chosen the other box they would have won 8 stickers (regret). It was not until children were 7–8 years old that they rated themselves as more happy on learning that they could have won nothing (relief).

Weisberg and Beck [36] were the first to claim positive evidence for when children experienced counterfactual emotions. But there was some uncertainty about whether this result was reliable. One concern was methodological. Many researchers in developmental psychology, Donaldson being the most famous (see Donaldson [11]), have raised questions about repeatedly questioning young children. The concern was that when asked to rate how they felt about their winnings a second time, children thought they should change their response. While this did not explain any difference between

regret and relief trials (because one should not simply change the response, but change it in the appropriate direction), it raises doubt over the result. Indeed, Rafestseder and Perner [29] found evidence to suggest this was the case. Children were more likely to show regret-like responses when they rated twice than in a single rating condition. Thus, Rafestseder and Perner suspected that the evidence of regret in Weisberg and Beck's task was really a methodological artefact—and that convincing evidence of regret is not seen until around 9 years of age. We return to their important series of experiments below.

However, the problem with repeated questioning was also identified by other researchers. In studies by O'Connor et al. [25] and us (Weisberg and Beck [35]) a different way of rating emotions was used: children made an initial rating on a smiley face scale, but the second rating, made after learning about the contents of the other box, was made by indicating one of three arrows. The arrows were arranged so that one pointed left along the scale indicating 'sadder', one pointed right along the scale meaning 'happier', and the third pointed to the initial face meaning 'the same'. Another strategy used by O'Connor et al. [25] and Burns et al. [7] that avoids problems with repeated questioning is to use baseline trials. In these trials the contents of the chosen and unchosen boxes are the same (e.g. both contain 1 sticker). This means that children should not experience a counterfactual emotion (and change their rating) on learning the contents of the unchosen box. All three of these studies found evidence of regret at an earlier age than that reported by Rafetseder and Perner (9 years). O'Connor et al. and Burns et al. reported experience of regret at 6 years, whereas Weisberg and Beck found some evidence of regret in children as young as 4. We return to the question of when children experience counterfactual emotions, and what this means for our understanding of the role of conditional reasoning in counterfactual emotions below.

There was another concern about the Weisberg and Beck [36] findings. Did the task really require children to engage in counterfactual thinking? Recall that we had coded children as experiencing regret if they rated themselves less happy on seeing the contents of the unchosen box than when they only knew the contents of their chosen box. This is because we assumed that they were thinking something of the type 'If I had chosen that box, I would have had more stickers'. But there is another possible explanation for their ratings. Perhaps children were rating only their reaction to reality. If this were the case, while children might be happy when they won two stickers from their chosen box, they might be frustrated or angry that they did not win the eight stickers in the unchosen box. This frustration might lead to a

lower rating on the scale, but not as a result of counterfactual thinking (or conditional reasoning). This serious possibility prompted us to run a further experiment, in which, based on the adult social psychology literature, we hoped to manipulate the likelihood of counterfactual thinking.

It is well established in the adult literature that people are most likely to engage in counterfactual thinking if they are personally involved in the event and if their actions have been a cause of the outcome. For example, to develop the restaurant scenario above, people are more likely to think counterfactually if they were the one making the choice between dishes than if it were imposed on them (Wells and Gavanski [37] use a similar narrative). In our standard version of the regret boxes task, children chose between the two boxes. So, even though it was an uninformed choice between two apparently identical boxes, it wasl the child's choice that determined the outcome (In actual fact, it was the experimenter's sleight of hand, but the child did not know that). In other conditions in our new study, we determined which box the child received by overt chance. In one condition the experimenter rolled a die that determined which box s/he received. Because children might find this version of the game aversively boring because they had little to do, we introduced a third 'mid-way' condition in which the child rolled the die. We found that children aged 5- to 8-years-old were influenced by our manipulation. Children in the original 'choice' condition showed regret (and indeed relief in some cases) just as they had done in our previous study. But in the other two conditions the change in emotion was muted. This was more so when the experimenter threw the die than when the child threw the die. This gave us confidence that children really were experiencing counterfactual emotions in our task. The opportunity to experience frustration was equal across all conditions: in each you failed to win 8 stickers. Yet, the conditions differed in how likely counterfactual thinking was. To date, we see this study as the most compelling evidence that children as young as 5 years old can experience counterfactual emotions.

The question as to what age regret is first experienced has yet to be conclusively answered. In our studies (Weisberg and Beck [35,36]) we reported regret from about 5 years (with some hint of regret even at 4 years in one study). However, O'Connor et al. [25] found no regret in 4- and 5-year-olds, but did find evidence that 6-year-olds could experience regret. Remember also that in the first study investigating children's experience of regret, 5-year-olds did not show evidence of the counterfactual emotion even though they could answer counterfactual conditional questions appropriately (Amsel and Smalley [1]). These findings might be reconciled by differences in samples or perhaps because children find the comparison between the actual

and counterfactual prizes easier in some studies compared to others: Amsel and Smalley used prizes of qualitatively different values: a figurine versus stickers, while in Weisberg and Beck's study children could win quantitatively different numbers of stickers (although this alone cannot explain the discrepancy between Weisberg and O'Connor as both used stickers). However, a rather more worrying discrepancy and contrasting claim emerges from work by Rafetseder and Perner [29]. As we mentioned above, in their study they removed the double questioning choosing instead to ask children questions about target trials (in which the unchosen box contained a better reward than the chosen one) and baseline trials (where the unchosen box contained the same prize as the chosen one). This meant they could ask the rating question only once, after the contents of the unchosen box had been revealed. Rafetseder and Perner found that only by 9 years of age could they confidently say that children were experiencing regret. There was some evidence that a minority of 6-year-olds experienced some regret, but this was clearly not as strong as in the other studies.

The discrepancy in when children are reported to experience regret is rather difficult to explain, and we hope that future empirical work will resolve this. The key elements of the tasks used by the different groups are largely shared—an apparently arbitrary choice is made between two boxes that are identical (Rafetseder et al., and Weisberg and Beck) or similar (O'Connor et al. used boxes of different colours with identifying images on them). One difference between the two studies is the types of scale used (Rafetseder and Perner used an 8 point scale and a computerized continuous scale, whereas we and O'Connor et al. used shorter 5 point scales with three categories being used to make the 'happier', 'sadder' and 'the same' response). However, it is difficult to think why these differences should matter. A second difference is that the children who showed early regret were native speakers of, and tested in, English, whereas Rafetseder and Perner's samples were German speaking. But, although counterfactuals are expressed differently across languages (see e.g., Iatridou [21]), there is no reason to think that the ability to think counterfactually differs across different language speakers (see Au [2]). A third observation is that, like Amsel and Smalley, Rafetseder and colleagues used some trials in which prizes were qualitatively different (in Experiment 1) where young 6-year-olds failed to show regret the comparison was between 1 and 5 candies, but in Experiment 3 where the first positive evidence of regret was seen in 9-year-olds one trial involved a single unattractive 'skin-sticker' and a counterfactual very attractive 'skin-sticker', Future work should investigate whether changes in the actual and counterfactual prizes might begin to reconcile the differences

between Rafetseder, O'Connor and Weisberg's samples. A final observation is that although Rafetseder and Perner's regretters seem rather old compared to the children claimed to experience regret by Weisberg, O'Connor and colleagues, another study converges on this age. Guttentag and Ferrell [18] found that children did not show anticipated regret until they were 9 years old. Anticipated regret was evidenced in a boxes guessing game where children had to predict what they would like to see in the unchosen box. Only children aged 9 and older made the self-protective prediction that they would like to see a worse prize in the unchosen box compared to the prize they had won. Similarly, children at this age understood why it might be better not to know what was in the unchosen box. Although this anticipated regret task is rather different from the experienced regret tasks described already, the similarity in age to Rafetseder and Perner's findings suggests that a closer consideration of the predictive and reflective demands in the different versions of various regret tasks might be important.

In summary, while we have yet to learn exactly when children do experience counterfactual thinking, one conclusion is consistent with the findings from all these studies. Reasoning with counterfactual emotions emerges later than children's ability to engage in conditional reasoning and, indeed, emerges later even than conditional reasoning with counterfactual content. This highlights an important aspect of how conditional reasoning is deployed in everyday life, for example, to underpin counterfactual emotions: it is not enough simply to be able to generate counterfactual conditionals. More is needed. For the next section of this paper we speculate about what this might be.

4. Spontaneous Counterfactual Thinking

One possibility is that once children have the competence to do counterfactual conditional reasoning, they do not do it spontaneously in the same way that adults do. In other words, their performance in real life might not always show evidence of what they are capable of. We investigate two aspects of spontaneous counterfactual thinking: automaticity and biases in thinking. N.b. both Beck et al. [4] and Rafetseder and Perner [29] used the term 'spontaneous' to describe generating and considering counterfactual worlds within the context of the counterfactual task. Here we go further speculating about children's ability to think counterfactually independently, that is, when they do so without any adult (or experimenter) scaffolding.

First, when adults experience negative events it often appears to us that we cannot help but think of the better alternative. For example, when you leave the house ten minutes late to get to the station and miss your train by a moment, the thought 'If only I had left the house earlier, I would have caught the train' seems to spring automatically to mind. In order to test whether adults genuinely engage in counterfactual reasoning automatically, Goldinger et al. [16] asked adults to judge the extent to which victims in various vignettes were to blame for the negative outcome that they encountered. Blaming the victim is more likely when one allows counterfactuals in which s/he could have avoided the negative outcome to influence an evaluation. Thus, if counterfactuals are generated automatically, but do not always influence our judgments, Goldinger et al. reasoned that they must typically be suppressed or discounted. The exact process remains to be specified: one might think of the counterfactuals as being inhibited or the individual may need to weigh up the significance of the counterfactual. Either way, the impact of the counterfactual on the blame judgment is tempered by subsequent processes. They hypothesised that if they interfered with participants' ability to do this then they should see an increase in victim blaming. In order to disrupt the suppression or discounting of counterfactual thoughts these authors used a working memory load (participants had to hold a list of numbers in mind) and, indeed, they found that adult participants (especially those with low working memory span) were more likely to blame the victim when they were under a working memory load. It might be that working memory specifically is involved in managing these counterfactual representations, or that the working memory task is imposing a more general 'cognitive load' which is disrupting participants' reasoning. In either case, the results suggest that adults do automatically generate counterfactuals (but normally suppress or discount them).

Thus, one performance aspect of counterfactual reasoning in everyday life is that even children who are competent at counterfactual reasoning may not yet do it automatically. It is a common model for developing expertise that with increased competence comes automaticity: for example, when one is learning to drive a car one must think explicitly about each subtask. But as an expert car driver, the process is automatic. Perhaps counterfactual reasoning is like this too, to some extent. For child novices the process needs to be prompted. For example, in an experiment 'What if you had won the other box, how would you feel?' or in real life 'What if you hadn't hit him, would he be crying?'.

A different performance aspect of adults' counterfactual thinking is the type of event which is likely to trigger counterfactual thinking. Adults are

susceptible to various biases about what kind of events lead them to counterfactual thoughts. For example, adults are most likely to engage in counterfactual thinking when they experience a negative (compared to positive outcome) or when events were under (rather than out of) their control: counterfactual thoughts are more likely when one fails an exam compared to passing it, and tend to focus on things one could have changed (working harder or not going out compared to the questions being easier or the examiner accidentally leaving the answers on your desk). Note that showing a bias in when one is more likely to engage in counterfactual thinking is distinct from whether these counterfactual thoughts are truly automatic (i.e. are always and uncontrollably generated in certain situations). It is possible that children's counterfactual thinking, while competent, may not show the same biases as adults and these biases may be developed during childhood. In other words, when children do engage in counterfactual thinking (prompted or automatically), they may be equally likely to do this regardless of circumstance. Perhaps the biases we see in adult counterfactual thinking are the result of children learning which events are useful to dwell on for future learning. There is only a little evidence on this. Guttentag and Ferrell [19] found that when children heard stories that contrasted characters who had acted typically or atypically, or events that resulted from commission rather than omission, it was not until they were 7 years that, like adults, they judged that the person who had acted atypically, or committed rather than omitted, would feel worse than the other (see also Powell et al. [27]). Other biases may be seen earlier in development. Meehan and Byrne [24] reported that children as young as 6 were susceptible to temporal biases in their counterfactual thinking. They heard about two people playing a game of chance where each in turn picks a coloured card. If they pick the same colour they win, but if the cards are different both players lose. Six-year-olds, like adults, were more likely to make counterfactual changes to the second players' card than the first. For example, imagine John goes first and picks red, then Bob goes second and picks blue. Children were more likely to say 'If only Bob had picked a different card, they would have won' rather than say the same thing about John. Finally, German [14] found that 5-year-olds showed a negativity bias, like adults, in their counterfactual thoughts. They were more likely to consider how things could have been in stories where things went wrong than when things went well. This is one of the most pervasive biases in adult counterfactual thinking and so perhaps it is unsurprising that it is the bias for which we have the earliest evidence. Yet in all these cases, the evidence for children's sensitivity to the various biases emerges at an older age than we believe children can engage in counterfactual conditional

reasoning if prompted. Thus, it remains possible that even when children can do counterfactual reasoning they are not influenced by the same contextual factors that influence adults' spontaneous counterfactual thinking.

5. Comparing the Real and Counterfactual World

A different explanation for the delay between counterfactual reasoning and counterfactual emotions is that the experience of counterfactual emotions may make further cognitive demands. This possibility is not incompatible with the spontaneous counterfactual reasoning possibility outlined above. It remains possible that children are prevented from experiencing counterfactual emotions both by the fact that they do not spontaneously generate counterfactuals, and because once generated they do not deal with them in the way that adults do. The additional cognitive demand that we think is critical for the experience of counterfactual emotions is the ability to make comparisons between two possible worlds. If we take as our example the child playing Weisberg and Beck's [36] boxes game—she may be able to generate a counterfactual conditional, 'If I had chosen the other box, I would have won 8 stickers' and she knows what the reality was 'I chose this box and won 2 stickers'. She may even know that 'If I had chosen the other box, I would have been very happy'. But to experience regret she also needs to make the comparison between reality and the counterfactual. Regret arises from the difference between reality and the perceived counterfactual alternative, not as a reaction to only one of these.

If the comparison between reality and the output from the counterfactual conditional is critical, then what kind of general cognitive process might be needed to support this? There are two possibilities: working memory, the ability to hold information in mind relevant to a task goal, and attentional flexibility, the ability to switch between task rules. Elsewhere, other researchers have suggested that both working memory (e.g. Byrne [8]) and flexibility (e.g. Guajardo et al. [17]) may be implicated in counterfactual reasoning, but they did not speak specifically to the demands of experiencing counterfactual emotions. One attempt to test whether attentional flexibility was implicated in children's developing regret was conducted by Burns et al. [7]. We took an individual differences approach, testing a large number of children on a battery of tasks. Children aged 4–7 years old completed a boxes task to see if they experienced regret. We also completed measures of working memory, attentional flexibility, inhibition and a measure of language ability. The working memory measure involved counting the number of shapes on

a series of slides on a computer screen. Once the series had been completed children were asked to recall the total numbers in order. For example, in a two slide sequence where the first slide had 4 squares on it, and the next had 2, children would need to recall '4, 2'. The measure of working memory was how long a list of numbers the child could recall. The measure of attentional flexibility involved cartoon faces that appeared on the left or right of the computer screen. Sometimes they looked straight down and sometimes they looked diagonally across. Children responded with buttons on the left and right. They had to press the button the eyes were looking towards, which involves flexibly switching between two rules 'press the button on the same side' and 'press the button on the other side.' Our measure of inhibition also involved pictures appearing on each side of the screen, but this time the child had simply to press the corresponding button: there were cat and monkey pictures and cat and monkey buttons on the left and right. This Simon task (Craft and Simon [10]) measures inhibition because it is hard to resist pressing the button on the same side as the picture when in fact you should press the one on the other side. For example, if the cat button is on the left, and the cat picture appears on the right even adults are slower to respond than if the picture appears on the congruent left-hand side. Finally, the measure of receptive vocabulary required children to identify which of four pictures words referred to. Our analysis of the data pointed to a rather simple model of the general cognitive demands that constrain the experience of regret. Whether or not children experienced regret was predicted by only one measure: attentional flexibility. This supports the argument that one reason why children who are capable of counterfactual reasoning do not experience regret is that they cannot move flexibly between the counterfactual and real worlds, i.e. they lack the cognitive skill to make comparisons between the counterfactual and the real world. Note that this does not mean that working memory, or, indeed, language and inhibition, are not required to experience regret – rather, in our sample they were not limiting factors.

6. Conclusion

We sought to review one particular way in which conditional reasoning impacts on our everyday psychological lives: in the experience of regret. To explore this we focussed on the development of reasoning and counterfactual emotions. Conditional reasoning itself is relatively easy for young children, but we made the argument that simply being able to reason does not necessarily reflect adult-like experience. Indeed, there is clear evidence

that reasoning with counterfactual content presents challenges to the young child. Furthermore, once counterfactual conditional reasoning is competent there are further developments. Children may not engage in counterfactual thinking automatically (as we believe adults do) and have yet to absorb the triggers for counterfactual thought that lead to the biases we see in adults. Finally, the experience of regret makes general cognitive demands on executive function, specifically attentional flexibility.

Our catalogue of these later developments should not to belittle the role of conditional reasoning in everyday experience. Without conditional reasoning we would not have rich reflective lives, in which we speculate about what might have been, feel consequent emotions and learn from our mistakes. Yet, to understand the role of conditional reasoning in real life thinking, we need to consider it within a diversity of other cognitive processes.

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