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Children's understanding of counterfactual and temporal relief in others



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ABSTRACT

Developmentalists have investigated relief as a counterfactually mediated emotion, but not relief experienced when negative events end—so-called *temporal* relief. This study represents the first body of work to investigate the development of children's understanding of temporal relief and compare it with their understanding of counterfactual relief. Across four experiments (407 children aged 4–11 years and 60 adults; 52% female), we examined children's ability to attribute counterfactual and temporal relief to others. In Experiment 1, 7- to 10-year-olds typically judged that two characters would feel equally happy despite avoiding or enduring an event that was unpleasant for one character. Using forced-choice procedures, Experiments 2 to 4 showed that a fledgling ability to attribute relief to others emerges at 5 to 6 years of age and that the tendency to make these attributions increases with age. The experiments in this study provide the first positive evidence in the literature as to when children can begin to attribute both counterfactual and temporal instances of relief to others. Overall, there was little evidence for separate developmental trajectories for understanding counterfactual and temporal relief, although in Experiment 4 there was an indication that, under

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scaffolded contexts, some children find it easier to attribute counterfactual relief rather than temporal relief to others.

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Introduction

Learning to navigate the social world involves becoming competent at keeping track of what other people are feeling (Lemerise & Arsenio, 2000; Saarni, 1999). Even very young children seem to grasp simple causal connections between states of the world and others' emotions—for example, that someone is happy because he or she is eating ice cream (Harris, 2008; Harris & Olthof, 1982). However, people's emotional states are very frequently determined not just by how the world actually is but also by their beliefs or thoughts about events that are not happening currently. In the light of this, developmentalists have tried to establish whether young children understand that someone's emotional state can be influenced by memories of things that happened in the past (Lagattuta & Wellman, 2001), by previous expectations regarding what was likely to happen in the future (Doan, Friedman, & Denison, 2020), or by thoughts about how things could have turned out differently (Beck & Crilly, 2009; Guttentag & Ferrell, 2008). If children are to become expert at tracking other people's emotional states, it is crucial that they grasp that others' emotions do not simply mirror current states of affairs but instead are affected by a range of mental states, including related memories, expectations, or thoughts about how things might have been. Such an understanding is likely to depend on more complex cognitive skills than the ability to make simple causal links between states of the world and emotions.

In this study, we focused on children's understanding of the emotion of relief in others. Understanding relief in others is likely to place particular cognitive demands on young children because relief, at least as characterized in the existing developmental psychology literature, is typically seen as a *counterfactual* emotion. Specifically, relief has been characterized as the positive emotion that occurs when someone compares what actually happened with a more negative state of affairs that could have occurred but did not (Guttentag & Ferrell, 2004; Weisberg & Beck, 2010). For example, one may be relieved that one caught the bus rather than missed it or that the teacher has decided not to set homework today.

Conceived of in this way, relief is considered to be the antonym of regret, which is a negative emotion that occurs when someone compares what actually happened with a more positive outcome that could have occurred but did not (Zeelenberg & Pieters, 2007). However, whereas a considerable body of research has examined both when children first begin to experience regret themselves and when they understand regret in others (e.g., Burns, Riggs, & Beck, 2012; Corbett, Feeney, & McCormack, 2021; Ferrell, Guttentag, & Gredlein, 2009; Habib et al., 2012; McCormack, Feeney, & Beck, 2020; Nyhout & Ganea, 2020; Rafetseder & Perner, 2012; Uprichard & McCormack, 2019), relief has received considerably less empirical attention. This is despite the fact that relief is considered to be a distinctive and highly prototypical emotion (Shaver, Shaver, Schwartz, Kirson, & Connor, 1987), is associated with emotion-specific facial expressions (Krumhuber & Scherer, 2011) and vocal expressions (see Sauter, 2017), and is readily identified cross-culturally (Cordaro, Keltner, Tshering, Wangchuk, & Flynn, 2016; Kamiloglu & Sauter, 2020; Sauter, Eisner, Ekman, & Scott, 2010).

What potentially complicates the study of children's understanding of the emotion of relief is the fact that it seems to be an emotion that can occur in two quite distinct scenarios. As recent conceptualizations of relief point out (Deutsch, Smith, Kordts-Freudinger, & Reichardt, 2015; Hoerl, 2015; Sweeny & Vohs, 2012), people experience relief when they compare reality with a worse counterfactual alternative (e.g., on learning that one narrowly avoided a prescription of nasty-tasting medication) but also following the end of an actual unpleasant experience (e.g., after completing a course of nasty-tasting medication). To our knowledge, what little developmental research exists on children's understanding of relief has only investigated it as a counterfactually mediated emotion (e.g.,

Guttentag & Ferrell, 2004; Weisberg & Beck, 2010) and has not explored temporal instances of relief that occur following the end of unpleasant experiences.

The current study therefore sought to investigate two questions: At what age do children first understand different instances of relief in others, and does children's understanding of the two types of relief have a different developmental profile? In particular, this is the first study, to our knowledge, to examine children's understanding of temporal instances of relief.

Being able to understand how others feel is an important sociocognitive tool, and given the apparent ubiquity in everyday life of the emotion of relief, understanding this emotion is likely to be beneficial in helping children to navigate the social world. For example, consider a case in which someone displays a positive emotion following the ending of an experience they find unpleasant such as smiling when having finished eating a vegetable they do not like. A smile under such circumstances does not indicate that the experience was enjoyable but rather indicates relief that it is over, and understanding this could be important in accurately keeping track of others' preferences. Moreover, in everyday life, an understanding that a consideration of an unrealized counterfactual scenario might enhance someone's emotional state is frequently put to work in the context of consoling strategies—that is, pointing out to others that, even in a negative situation, “things could be worse.” Indeed, Payir and Guttentag (2016) directly examined whether children employ such consoling strategies and found that they were not commonly employed or deemed to be effective until late childhood (10–12 years). These authors speculated that this may be linked to difficulties in understanding relief, but as we discuss below, it is not yet known when children first understand that a consideration of a downward counterfactual may yield a positive emotion in others. These examples suggest that establishing when children understand relief with temporal or counterfactual precursors may be of practical significance as well as theoretical significance.

Two instances of relief

As we have pointed out, in psychology, relief is frequently depicted as a counterfactual emotion that arises after comparing the current state of affairs with a worse counterfactual alternative (e.g., Roese & Epstude, 2017). For example, an individual who has just come off a seemingly safe flight may feel relieved to learn that the plane narrowly avoided crashing. To experience relief in this context requires certain reasoning and evaluative skills; the individual must have an ability to imagine how events could have turned out differently (being on a plane that crashed) and subsequently judge their reality to be better than this imagined outcome. In other words, experiencing relief in this instance relies on advanced counterfactual thinking abilities (Roese & Epstude, 2017). There is substantial debate over when children possess adult-like counterfactual reasoning abilities (e.g., Beck & Riggs, 2014; Guttentag & Ferrell, 2008; Harris, German, & Mills, 1996; Nyhout & Ganea, 2019, 2020; Rafetseder, Schwitalla, & Perner, 2013). However, it is broadly agreed that counterfactual emotions, such as regret and counterfactual relief, emerge relatively late in childhood because of the nature of the counterfactual cognition required to experience them (e.g., Beck, Riggs, & Gorniak, 2009; Beck, Weisberg, Burns, & Riggs, 2014; Burns et al., 2012; Rafetseder & Perner, 2012). Moreover, as we discuss below, the ability to appropriately attribute these emotions to others also seems to develop relatively late (Weisberg & Beck, 2010).

It is possible, however, that not all experiences of relief rely on these types of counterfactual abilities. Indeed many psychologists, particularly those interested in pain, focus specifically on instances of relief that occur following the end of an unpleasant experience (e.g., Porreca & Navratilova, 2017). For example, an individual may feel relieved at the end of a particularly long and boring plane journey. A recent philosophical analysis (Hoerl, 2015) posited that relief experienced in this context, which primarily hinges on a realization that an unpleasant event is now over and in the past, is distinct from relief that involves making a counterfactual comparison with an unpleasant alternative that did not occur. Sweeny and Vohs (2012; see also Lorimer et al., 2022) provided initial experimental evidence to support this type of distinction. They found that participants who have completed an unpleasant task will engage in less counterfactual thinking than participants who narrowly avoided completing the same unpleasant task, yet both groups of participants reported feeling relieved. Here, we adopted the terminology used by Hoerl (2015) to differentiate between *temporal relief*, experienced following

the end of a negative experience, and *counterfactual relief*, experienced when comparing reality with a worse counterfactual alternative.

Hoerl's (2015) claims about relief raise important developmental questions. If experiencing these two forms of relief relies on separate cognitive processes, which potentially vary in terms of sophistication, do they emerge at different stages during childhood and does their emergence facilitate different behaviors? And, of particular relevance to the current study, do children understand one type of relief in others before they understand the other type of relief? As we have pointed out, the counterfactual reasoning abilities that are required for the experience of counterfactual relief seem to emerge relatively late in childhood and require a number of cognitive advances before they reach maturity (see Beck et al., 2014, for a review). By contrast, relatively little is known about the development of the temporal-cognitive abilities that may underpin temporal relief (see McCormack & Hoerl, 2017, for a review of relevant literature). Some research suggests that children as young as 24 months can think about the status of events as being complete or incomplete (Bauer & Mandler, 1989; Fenson & Ramsay, 1980), and 2- and 3-year-olds typically use the past tense reliably to refer to events that are complete (Shirai & Andersen, 1995; Shirai & Miyata, 2006). This ability to appreciate that an unpleasant event is over may be sufficient to experience temporal relief.

Although both types of relief may be seen as relying on a comparison between two models of reality (i.e., a current event vs. a past or counterfactual event), the two types of relief differ on the dimension that separates these two models (temporal vs. counterfactual). Counterfactual relief relies on a potentially more sophisticated comparison than temporal relief in that it requires one to simulate an alternative event by rejecting what one knows to be true about one's actual reality (e.g., simulating getting a painful dental surgery instead of a routine appointment), recognizing that this event was a possibility at one point in the past, and finally comparing this possibility with what actually occurred (i.e., getting a painful dental procedure would have been worse than a routine appointment). Temporal relief, by contrast, relies on a comparison between two *actual* events that occur in succession and thus might not rely on complex counterfactual reasoning such as mentally undoing a past event to simulate an alternative current reality and acknowledging that both the actual reality and counterfactual reality were possibilities (Beck et al., 2014). Therefore, it is plausible that experiences of temporal relief emerge earlier in childhood than counterfactual relief and, concordantly, that children understand the circumstances in which others experience temporal relief before they understand others' counterfactual relief. An alternative possibility is that experiencing and understanding both types of relief rely on similar cognitive prerequisites such as the ability to evaluatively compare a nonactual negative experience (either past or counterfactual) with an actual positive one and thus that the abilities to experience and/or understand both emerge concurrently.

Developmental research into relief

Much of the previous developmental research on regret and counterfactual relief has sought to determine the age at which children first have the ability to *experience* these counterfactual emotions. Typically, developmental studies measuring an experience of counterfactual relief or regret use forced-choice paradigms in which children are required to make a decision between two boxes in order to obtain a small prize (Amsel & Smalley, 2000). After children have seen the prize that they won from their chosen box, they are shown the contents of the unchosen box, which are better (in the case of regret trials) or worse (in the case of relief trials) than the prize obtained by the children, and emotional judgments are elicited. Although there are minor methodological differences across the procedures (see McCormack, O'Connor, Beck, & Feeney, 2016, for discussion), most studies employing these paradigms suggest that by 6 or 7 years of age the majority of children can experience counterfactual relief and regret (e.g., Guerini, FitzGibbon, & Coricelli, 2020; McCormack et al., 2016; Weisberg & Beck, 2010).

Previous developmental research into counterfactual emotions has also attempted to establish the age at which children can first *understand* these emotions in others (e.g., Beck & Crilly, 2009; Begeer, De Rosnay, Lunenburg, Stegge, & Terwogt, 2014; Ferrell et al., 2009; Guttentag & Ferrell, 2004; Weisberg & Beck, 2010). Weisberg and Beck (2010) provided evidence of a developmental lag between the ability to experience counterfactual regret and relief and the ability to infer these emotions in

others. This is unsurprising given the higher cognitive demands in attributing emotional states to others (e.g., [Arsenio, Gold, & Adams, 2006](#)). [Weisberg and Beck \(2010\)](#) found evidence that children aged 6 and 7 years could experience counterfactual relief in a box-choosing task but were unable to infer this emotion in a toy puppet playing the same task. Therefore, the authors found no positive evidence of an understanding of counterfactual relief in children up to 8 years of age despite there being some evidence that children at this age can understand regret in others (e.g., [Ferrell et al., 2009](#)). This is consistent with some (albeit limited) evidence to suggest that the ability to experience regret also emerges earlier than the ability to experience counterfactual relief (e.g., [Guerini et al., 2020](#); [McCormack et al., 2016](#); [Weisberg & Beck, 2010](#); but see [Van Duijvenvoorde, Huizenga, & Jansen, 2014](#)).

Another way to investigate children's understanding of emotions is to ask participants to make comparative emotional judgments between characters in vignettes. [Guttentag and Ferrell \(2004\)](#) took this approach to explore children's understanding of regret and counterfactual relief in the context of event mutability. In each of their stories, there were two characters who engaged in different behaviors to obtain identical outcomes. For example, in one story a character cycled a typical route to school, whereas the other character cycled an atypical route. Both characters hit a branch and fell over. Adult literature suggests that actions that are easier to cognitively mutate (e.g., atypical decisions, acts of commission) are stronger triggers for counterfactual thoughts and subsequent emotions such as regret ([Kahneman & Miller, 1986](#)). In line with this, [Guttentag and Ferrell \(2004\)](#) found that adults and 7-year-olds, but not 5-year-olds, typically judged that characters who engaged in atypical or commissive behavior would feel worse than characters making typical or omissive actions. By contrast, in the counterfactual relief stories, when the outcomes were positive, the 5- and 7-year-olds typically judged that the two characters would feel the same regardless of their behavior. The authors reasoned that when the outcome was positive, children based their judgments on reality and neglected to take the counterfactual world into account. This was taken as evidence for a lag between the development of understanding regret and counterfactual relief. However, Guttentag and Ferrell's study only examined whether children were sensitive to the relation between the mutability of decisions and relief, and it is possible that this sensitivity emerges later than a more basic understanding of relief itself. Therefore, although previous research has shown when children can first begin to attribute regret to others, no studies of which we are aware have found positive evidence of when children can first begin to understand counterfactual relief in others. Moreover, to our knowledge no developmental work has previously investigated children's understanding of temporal relief.

In summary, what little developmental research exists on relief has only investigated it as a counterfactual emotion but has not explored children's ability to experience or understand temporal instances of relief. Recent theoretical distinctions between these two manifestations of relief ([Deutsch et al., 2015](#); [Hoerl, 2015](#); [Sweeny & Vohs, 2012](#)) raise important developmental questions regarding their emergence during childhood. The current study is the first to examine the emergence of temporal relief during childhood and sought to explore children's ability to understand both temporal and counterfactual instances of relief in others. An observation of a developmental lag could provide preliminary evidence for [Hoerl's \(2015\)](#) distinction between two types of relief that rely on separate cognitive prerequisites. On the other hand, if the abilities to understand both types of relief emerge concurrently, this might suggest that the two instances of relief rely on similar cognitive prerequisites such as the ability to maintain and compare two models of reality in working memory (i.e., the current reality vs. the past reality or vs. the avoided counterfactual reality).

The current study

The current study examined when children can first attribute relief to others by examining their inferences about the relative emotions of two contrasting story characters. To compare children's understanding of counterfactual relief with their understanding of temporal relief, we devised two versions for every story: a counterfactual version, in which two characters *avoided* a potentially aversive episode, or a temporal version, in which two characters *endured* this episode for a short time. Crucially, we manipulated characters' preferences so that one character strongly disliked the experience delivered in the avoided or endured episode, whereas the other character felt neutral toward it. The

character who strongly disliked the experience (the “target” character) had grounds to feel relieved at the end of it or avoidance of it, whereas there was no obvious reason for the character who was neutral about it to feel this way. For example, in one story Sally strongly dislikes the taste of strawberries, but Anne thinks they taste okay. The two characters either avoid a prescription of strawberry-flavored medicine (in the counterfactual version) or are required to drink strawberry-flavored medicine for a short while (in the temporal version). In both versions of the story, Sally has grounds to feel relieved because the experience she strongly dislikes has been avoided (counterfactual) or is now over (temporal), whereas Anne has no grounds for feeling this way.

In our experiments, participants made emotional judgments in three counterfactual relief scenarios and three temporal relief scenarios. Consistent with [Guttentag and Ferrell's \(2004\)](#) procedure, at the end of each story participants were asked to judge which character would feel “happier” (i.e., we avoided verbal reference to “relief” because young children might not have acquired this term).¹ If participants judged that the target character was happier, we interpreted this as an indication that they were sensitive to the relief experienced by the characters. In Experiment 1, we presented these stories to children aged 7 to 10 years and an adult comparison group. These age groups were selected given previous research suggesting that 6- and 7-year-olds are able to experience counterfactual relief. As in [Guttentag and Ferrell's \(2004\)](#) study, participants in Experiment 1 were given three options when asked to judge which character feels happier; they could choose the “target” character, they could choose the “non-target” character, or they could answer “both feel the same.” In Experiments 2 and 3, we aimed to prompt children to think about the emotional differences between the two characters by removing this “both” option. Experiment 4 sought to reduce the cognitive demands of the materials further in order to scaffold even younger children's ability to attribute relief to the characters. In Experiment 4, the stories were simplified such that participants were only required to think about the characters' preferences toward one stimulus rather than two stimuli. Given the paucity of research into children's understanding of relief, the current experiments were largely exploratory. However, Experiments 3 and 4 sought to confirm and explore alternative explanations for findings from the first two experiments.

Experiment 1

Method

Participants

In total, 110 children aged 7 to 10 years and 30 adults participated in this experiment. Child participants were divided into two age groups on the basis of chronological age, with a younger group of children aged 7 and 8 years and an older group of children aged 9 and 10 years. The 7- and 8-year-olds consisted of 62 children (41.9% female) aged 84 to 107 months with a mean age of 96.42 months ($SD = 7.29$). The 9- and 10-year-olds consisted of 48 children (41.7% female) aged 108 to 131 months with a mean age of 119.21 months ($SD = 6.45$). Adult participants (83.3% female) were aged 18 to 41 years with a mean age of 23.73 years ($SD = 6.20$). Children were recruited via parental consent letters that were sent to schools and summer schemes in a region of Northern Ireland local to the first author's university. Adult participants were either paid volunteers, recruited via an advertisement placed around the university campus, or psychology students who received course credit for their psychology undergraduate course. Although G*Power analyses ([Faul, Erdfelder, Lang, & Buchner, 2007](#)) estimated that the smallest per-group sample size necessary to yield an odds ratio (OR) of 10.52 with power = .95 ($\alpha = .05$) for any of the experiments reported here was 26, the final sample size of each age group for this and the following experiments was determined by number of parental consent letters returned. This OR was based on the difference in proportion of target judgments made by adults (65%; $n = 18$) and 7-year-olds (15%; $n = 17$) in a study with a similar design investigating children's understanding of counterfactual relief ([Guttentag & Ferrell, 2004](#)).² Due to the demographics of the local pop-

¹ Children do not tend to acquire the vocabulary for complex emotions, such as regret, until 9 years of age (e.g., [Dale & O'Rourke, 1981](#)). Therefore, we felt that using the word “relief” would have added unnecessary lexical demands to the task.

² To obtain this value of 10.52, the odds of judgments being the target in the adult group (65/35) were divided by the odds of judgments being the target in the 7-year-old group (15/85).

ulation (98.2% White according to the most recent population census), participants in this and the following experiments were predominantly White and from lower- to middle-class socioeconomic backgrounds. Data for all four experiments were collected between April 2019 and September 2020.

Materials

Six two-character vignettes were used in this experiment. They concerned a journey, housework, taking medicine, events at a party, singing in school, and playing games. We devised a counterfactual and temporal version for each story such that characters either avoided or endured an unpleasant experience respectively (the exact wording of the stories can be found in [Appendix A](#), whereas the text and accompanying images are reproduced in the online [supplementary material](#)). Every story followed the same basic structure. At the beginning of each story, participants were informed about two characters and their preferences toward two stimuli. Both characters always loved one stimulus but felt differently toward the other stimulus; one character always strongly disliked this stimulus, and the other character had neutral feelings toward it.³ For example, in one story Sally and Anne both love chocolate, whereas Sally finds strawberries disgusting and Anne thinks strawberries taste just okay. After the preferences were introduced, the stories proceeded differently depending on whether the counterfactual or temporal version was presented. In the counterfactual versions of the stories, the two characters avoided the stimulus they felt differently about and instead received the stimulus they both liked. For example, Sally and Anne narrowly avoided needing to drink strawberry medicine and were given chocolate medicine that they both liked instead. By contrast, in the temporal versions, the two characters endured the stimulus they felt differently about for a while before this experience ended and was replaced by the stimulus they both liked. For example, Sally and Anne were required to drink strawberry medicine for a while and were then given chocolate medicine instead. In both versions of the story, at the end participants were asked to judge “Who feels happier now?”.

[Hoerl \(2015\)](#) noted that, even if there is a difference between counterfactual relief and temporal relief, in many cases where an individual has reason to feel counterfactual relief about an outcome not being as bad as it could have been, this individual may also feel temporal relief because the aversive state of being anxious about the possibility of a worse outcome is over. Conversely, in many cases where an individual has reason to feel temporal relief about an aversive event being over, this individual might also feel counterfactual relief that the event was less aversive than it could have been, which might not be known until it is over. Thus, we designed the stories to minimize interpretations that characters might experience both types of relief. In the temporal relief stories, characters were always aware of how events were going to unfold. This was to reduce possible interpretations that characters felt counterfactually relieved that the series of events could have been worse or went on for longer than they expected.⁴ For example, in the medicine scenario, the characters knew that they were going to get strawberry medicine first but would then get chocolate medicine the next time they went to the doctor’s office. Therefore, it seems unlikely that characters derive counterfactual relief from thinking, “thank goodness I didn’t get strawberry medicine this time.”⁵ In the counterfactual versions, the characters were given no expectations about how events were going to unfold and, importantly, learned about the actual outcome and the counterfactual outcome at the same time to eliminate the possibility that they felt temporally relieved because an unpleasant period of anticipatory anxiety about an undesired outcome was over. For example, in the medicine scenario, the characters were told, “You were about to drink strawberry medicine, but instead you will drink chocolate medicine.” This is consistent with forced-choice paradigms used to measure experiences of counterfactual relief in which children also

³ The non-target character had neutral rather than positive feelings toward the stimulus to prevent children from judging that the target character was happier not because they believed the target character experienced relief but rather because they believed the non-target character was disappointed.

⁴ This is particularly important given recent evidence suggesting that young children can understand and integrate others’ expectations into judgments about their happiness ([Asaba, Ong, & Gweon, 2019](#); [Lara, Lagattuta, & Kramer, 2019](#)).

⁵ One might still argue that it is possible for characters to experience counterfactual relief from thinking “That event wasn’t as bad as I thought it was going to be.” However, this interpretation seems unlikely in our stories given that participants were explicitly told how the characters feel about the events and were given no reason to think that these preferences would change throughout the stories. Moreover, the preference symbols at the end of the stories reminded participants that the characters still feel the same way about events even after going through them.

have no prior expectations about what prizes they might or might not win (e.g., Amsel et al., 2003; Weisberg & Beck, 2010). The exact wording of stories presented to participants in Experiment 1 can be found in [Appendix A](#).

The stories were presented on a touchscreen device using the open-source stimulus delivery program OpenSesame (Mathôt, Schreij, & Theeuwes, 2012). The program displayed cartoon images of the stories alongside prerecorded narration to ensure that volume and tone of voice were standardized across participants. Throughout the stories, symbols were used to indicate the characters' attitudes toward relevant stimuli. A green thumbs-up sign indicated that a character really liked something, a red thumbs-down sign indicated that a character really disliked something, and a yellow sideways thumb indicated that a character felt neutral about something (see [Fig. 1](#)). When participants were asked to judge which character feels happier, three buttons were displayed on the screen; one button depicted the target character, a second button depicted the non-target character, and a third button depicted both characters. Each button contained a cartoon image of the character and symbols of their attitudes toward relevant stimuli (see [Fig. 1A](#)). This reminded participants of the important attitudinal differences necessary for making the emotion judgments. Participants were asked to tap on the character they thought was "happier now." The plug-in Mousetrap (Kieslich & Henninger, 2017) was used to record participants' touch responses.⁶

Procedure

Stories were presented to participants individually in a quiet room at schools or at a developmental lab at the university of the first author. Prior to the stories, child participants were introduced to the three symbols that were used throughout the stories and were taught that these indicated when a character really loved, disliked, or felt neutrally about something. Children were then presented with a practice story on the touchscreen device. Adult participants did not receive training for the attitude symbols, and their session began with this practice story. Apart from this difference, the procedure was identical for adult participants. In the practice story, participants were introduced to two characters, Fred and Ryan, who felt differently toward ice cream. Participants were asked, "Who feels happier about having ice cream for dessert: Fred, Ryan, or do they feel the same?" As the experimenter mentioned each of the options, they pointed at a corresponding button on the touchscreen device. Participants were asked to tap on one of the three buttons to answer the question. If participants gave an incorrect response, they were reminded of the characters' attitudes and prompted to try again until they got this answer correct. This practice story ensured that participants understood how the symbols were used throughout the stories and allowed them to become familiar with using the touchscreen device to make judgments. The vast majority of children across all four experiments made the correct response to the practice story the first time.

After the training phase, participants were presented with the six stories measuring their understanding of relief. Participants were assigned to one of six lists constructed so that each participant received three counterfactual versions and three temporal versions of the stories and never received a counterfactual version and a temporal version of the same story. Three different assignments of stories to list were devised and then reversed, resulting in six different lists. These lists were created to ensure that the counterfactual and temporal versions of each story were presented an equivalent number of times. Assignment of participants to lists was counterbalanced, and the order of story presentation within each list was randomized (further information on list assignment can be found in the [supplementary material](#)). In every story, directly after characters had been introduced, participants were required to answer three questions checking their understanding of the characters' attitudes. Given that these attitudinal differences theoretically determined which character had grounds for experiencing relief, it was crucial that participants could remember this information while reading

⁶ Our materials were piloted with 30 adults on Prolific, an online recruitment platform, to ensure that the contents of the stories induced attributions of the target emotions. After piloting the stories, we decided to include visual reminders of the characters' attitudes on the same screen as the final emotion judgment. Moreover, we changed the final question from "Who feels happier?" to "Who feels happier now?" to make it clearer that we were asking about the characters' emotional states at the end of the stories rather than a composite measure of how the characters felt throughout the stories. Performance in Experiments 1 and 2 suggests that our stories did indeed induce attributions of the emotion of relief in adults.

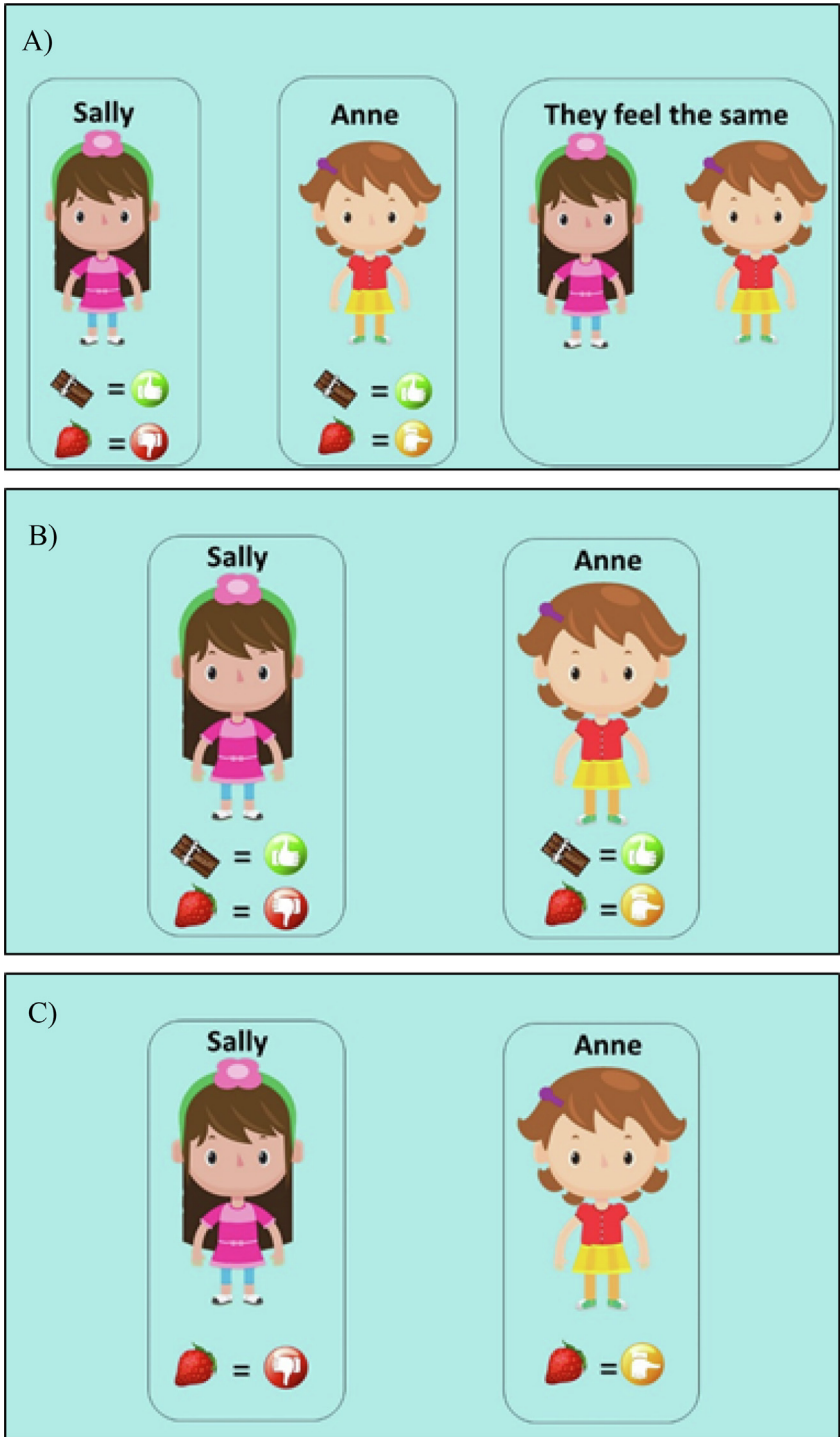


Fig. 1. Response screens presented to participants at the end of a vignette in Experiment 1 (A), Experiments 2 and 3 (B), and Experiment 4 (C). Participants were asked “Who feels happier now?” and were required to tap on one of the buttons on the response screen to indicate their answer.

the rest of the story. If participants gave incorrect answers, they were reminded of the relevant attitudes and prompted to answer the memory question again. Participants could not proceed to the next part of the story until they gave correct answers for each of these three memory checks. If a participant was prompted to attempt the memory check again, this was recorded as an error. Based on inspection of outliers across all four experiments, if participants made 3 or more errors in a given story, their response to that story was excluded from the final analysis. Furthermore, data from participants who made 7 or more errors across the 18 memory checks (i.e., answered more than 33.3% of the memory checks incorrectly) were excluded from the analyses.

At the end of each story, participants were asked to indicate which character feels happier now. As in the practice story, three buttons were displayed on the touchscreen and participants were prompted to tap on one of three options: the target character, the non-target character, or both characters (see Fig. 1). After participants had indicated their answers, the next story loaded and child participants were given a sticker for listening well. This was repeated until all six stories were completed. The experimental session lasted approximately 15 min. Ethical approval was received for this and the following experiments from the School of Psychology at Queen's University Belfast.

Results

First, we examined participants' responses to the memory checks. One participant in the 7- and 8-year-old age group made a total of 15 memory check errors across the stories. Therefore, this participant's data were excluded from subsequent analyses. The mean numbers of errors made from the remaining 7- and 8-year-olds, 9- and 10-year-olds, and adults were 0.69, 0.38, and 0.43 errors, respectively.

Next, we examined the emotion judgments made at the end of the stories. Participants selected one of three buttons to judge which character feels happier in three counterfactual and three temporal relief stories. These responses were coded as either "target character" (i.e., the character who had grounds to feel relieved), "non-target character," or "both characters" (i.e., both feel the same). As can be seen from Fig. 2, the modal response in the two child groups was "both" for the counterfactual and temporal story types. By contrast, the modal response in the adult group was "target" for both types of stories.

Of primary interest was whether selecting the "target character" differed by relief type (temporal vs. counterfactual) and, if so, whether this varied between age groups. We also wanted to explore whether participants' judgments differed across the six scenarios. To analyze the data, we used a mixed effects multinomial logistic regression model to examine the variables that predicted selecting the target character compared with selecting the non-target character or the "both" option. Models were fit using the *mclgit* package in R (Elff, 2020; R Core Team, 2020). Our approach consisted of initially fitting a full model, which included all theoretically relevant candidate fixed main effects and interactions, and then systematically removing components and reassessing the model fit until a final model was obtained (see Bates, Kliegl, Vasishth, & Baayen, 2015). Our full model included the fixed main effects of age group (7- and 8-year-olds, 9- and 10-year-olds, or adults), scenario (medicine, party, singing, games, journey, or housework), and relief type (counterfactual or temporal) as well as the two-way interactions between age group and relief type and between relief type and scenario. The adult age group and counterfactual relief type were used as reference categories. Given that every individual participant made judgments across six different trials, participant ID was also included as a random effect to control for the within-participant variance from each participant. In addition, previous literature has highlighted the risk of Type I errors when conducting analyses with mixed models that do not account for random effects (e.g., Barr, Levy, Scheepers, & Tily, 2013). For each step, the Bayesian information criterion (BIC), which assesses model fit while penalizing for complexity (Schwarz, 1978), was compared before and after removing an effect or interaction. If the removal of a given fixed effect or interaction resulted in a positive BIC difference of ≥ 10 (Δ BIC), that component was not included in the final model (see Raftery, 1995). Note that the random intercept of Participant ID was not removed at any step to allow all models to account for within-participant variance.

At the first step, we removed the Scenario \times Age Group interaction term (Δ BIC = 34.2). Then, the Age Group \times Relief Type interaction term was removed (Δ BIC = 22.1). Following this, the main effect

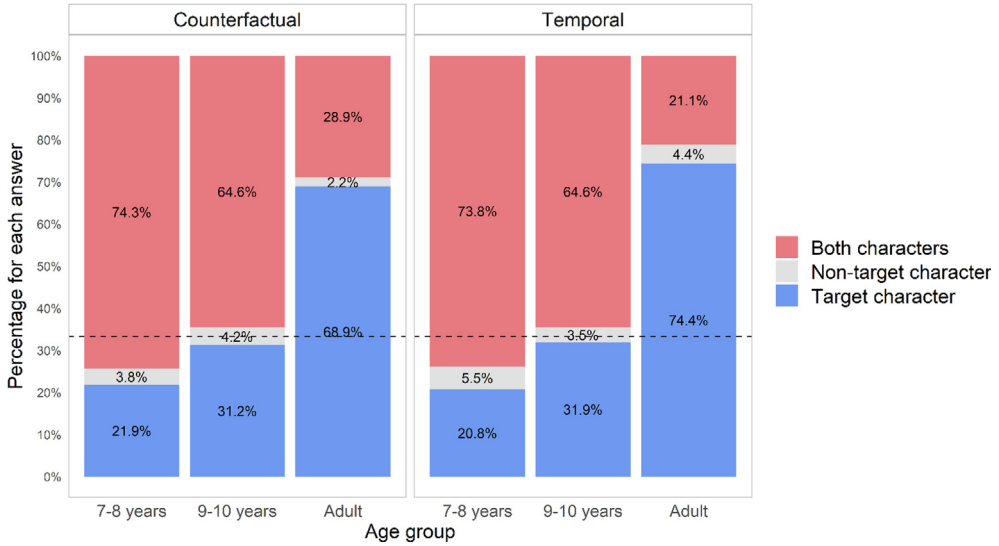


Fig. 2. Percentages of participants selecting “target character,” “non-target character,” and “both characters” in Experiment 1 as a function of age group and story type. The dashed line shows the chance level for selecting each answer (33.3%).

Table 1

Results of mixed effects multinomial logistic regression analysis for Experiment 1.

	β (SE)	Exp β	97.5% CI for Exp β
Target vs. both			
Intercept	1.54 (0.57)**	4.65	[1.30, 16.66]
Age group			
7–8 years	–3.55 (0.69)***	0.03	[0.01, 0.14]
9–10 years	–2.80 (0.72)***	0.06	[0.01, 0.30]
Relief type			
Temporal	0.17 (0.23)	1.18	[0.70, 1.99]
Target vs. non-target			
Intercept	3.88 (0.83)***	48.26	[7.54, 309.09]
Age group			
7–8 years	–1.30 (1.03)	0.27	[0.03, 2.73]
9–10 years	–0.47 (1.10)	0.63	[0.05, 7.37]
Relief type			
Temporal	–0.31 (0.45)	0.73	[0.27, 2.03]

Note. This table presents a comparison of “target” judgments versus “both” judgments (upper) and “target” judgments versus “non-target” judgments (lower). The adult group is the reference category for the age groups, and counterfactual relief is the reference category for relief type. McFadden’s $R^2 = .71$, Cox and Snell’s $R^2 = .79$, and Nagelkerke’s $R^2 = .89$. CI, confidence interval.

** $p < .01$.

*** $p < .001$.

of scenario was removed ($\Delta BIC = 50.7$). Next, the main effect of relief type was retained because the BIC comparison was not considered strong enough ($\Delta BIC = 9.9$). Finally, the main effect of age group was retained because the BIC difference was negative ($\Delta BIC = -7.8$). Therefore, the final model, outlined in Table 1 included only the main effects of age group and relief type.

As seen in Table 1, the adults were significantly more likely to select the target option over the “both” option when compared with the 7- and 8-year-olds ($p < .001$) and 9- and 10-year-olds ($p < .001$). However, the model did not indicate that the adults were more likely to make target judgments over non-target judgments when compared with the 7- and 8-year-olds ($p = .207$) and 9- and

10-year-olds ($p = .670$). Notably, when the 9- and 10-year-olds were set as the reference category for age group, the model revealed that the 9- and 10-year-olds were not significantly different from the 7- and 8-year-olds at selecting the target option over the “both” option ($b = -0.75$, $SE = 0.72$, $p = .214$, $OR = 0.47$, 97.5% confidence interval (CI) [0.12, 1.83]) or when selecting the target option over the non-target option ($b = -0.82$, $SE = 1.01$, $p = .415$, $OR = 0.44$, 97.5% CI [0.05, 4.24]). Importantly, the final model did not reveal relief type to be a significant predictor for selecting the “both” option over the target option ($p = .471$) or selecting the non-target option over the target option ($p = .495$).

Finally, we compared participants' judgments with chance performance (i.e., 33% accuracy). We ran binomial sign tests and Bayesian equivalents with default prior scales in JASP (JASP Team, 2020) to compare proportion of judgments in the counterfactual and temporal relief story types with what would be expected with chance performance for each age group. To maintain consistency with our primary analysis reported above, which relied on BIC for model reduction, we have also included a Bayesian metric in our comparison of target responses with chance. As a guide to interpreting strength of evidence in favor of the alternative hypothesis, Lee and Wagenmakers (2014) suggested a Bayes factor (BF_{10}) >10 to be considered strong, between 3 and 10 to be moderate, between 1 and 3 to be anecdotal, and <1 to indicate no evidence for the alternative hypothesis. Our analyses indicated that the proportions of target judgments made by the adults were above chance for the counterfactual ($p < .001$, $BF_{10} = 3.74e^9$) and temporal ($p < .001$, $BF_{10} = 1.27e^{13}$) story types. By contrast, the proportions of target judgments made by the 9- and 10-year-olds were at chance for the counterfactual ($p = .723$, $BF_{10} = 0.11$) and temporal ($p = .859$, $BF_{10} = 0.10$) story types. The proportions of target judgments made by the 7- and 8-year-olds were lower than what was expected from chance in the counterfactual ($p = .001$, $BF_{10} = 19.07$) and temporal ($p < .001$, $BF_{10} = 61.92$) story types.

Discussion

To summarize, across both counterfactual and temporal relief stories, the 7- and 8-year-olds and 9- and 10-year-olds typically judged that the characters felt the same, whereas the adults typically judged that the target character would feel happier. Our final model suggested that the adults were significantly more likely than both child age groups to make target judgments over judging that both characters felt the same. Moreover, our analyses indicated that, across all age groups, judgments did not differ between the two relief types. These findings suggest that, unlike adults, children up to 10 years of age do not typically display an ability to infer counterfactual or temporal relief in others based on preference differences.

These results are compatible with previous developmental research suggesting that children up to 8 years of age struggle to attribute counterfactual relief to others (Weisberg & Beck, 2010). Moreover, the responses from child participants were in line with those reported by Guttentag and Ferrell (2004), who found that in stories of counterfactual relief, where two characters made different decisions to obtain identical positive outcomes, 7-year-olds consistently judged the characters as feeling the same. Taken together, an initial interpretation of these findings is that children up to 10 years of age are incapable of understanding counterfactual and temporal relief in others.⁷ However, it is possible that the vignettes used in Experiment 1 might not have sufficiently prompted young children to draw a comparison between the two characters. Notably, in both the counterfactual and temporal versions of the stories, the two characters always ultimately received an outcome that they both liked equally. It is possible that this positive end to the stories served to mask any aversive event that had occurred previously (in the temporal versions) or that had nearly occurred (in the counterfactual versions). In other words, children may have focused only on the positive outcome that was equal for both characters. Relatedly, it is possible that the young participants interpreted the meaning of the final question “Who feels happier now?” as “Who feels happy now?” If the young participants did interpret the question in this way, judging that both characters feel the same would be a sensible response.

⁷ Note that point-biserial correlations revealed that, among the child participants, children who were older in months were somewhat more likely to make target judgments across both story types (see supplementary material for full report of these analyses). However, the proportion of target judgments from even the oldest children was still much lower than that of adults.

Experiment 2

In Experiment 2, we sought to investigate the possibility that our materials had not sufficiently prompted children to draw a comparison between the two characters. Participants were presented with stories identical to those used in Experiment 1. However, to encourage participants to focus on differences between the two characters' emotional states, we removed the "both" option from the final screen so that participants could only select the target or non-target character as feeling happier (see Fig. 1B). Thereby, participants were explicitly directed to draw a comparison between the two characters and the question was less likely to be misinterpreted as "Who feels *happy* now?" If young children still did not reliably select the target character above chance, this would support the notion that young children were truly unable to understand relief in the characters. We recruited a wider age range of children for this experiment to increase our chances of observing the age at which children first begin to demonstrate an understanding of relief in others.

Method

Participants

In total, 122 children aged 5 to 11 years and 30 adults participated in this experiment. Children were divided into three groups on the basis of chronological age. The youngest group of 5- and 6-year-olds consisted of 35 children (51.4% female) aged 60 to 83 months with a mean age of 73.86 months ($SD = 6.05$). The 7- and 8-year-olds consisted of 34 children (52.9% female) aged 84 to 107 months with a mean age of 91.74 months ($SD = 6.68$). The 9- to 11-year-olds consisted of 53 children (54.7% female) aged 108 to 142 months with a mean age of 124.89 months ($SD = 11.90$). Adult participants (46.7% female) were aged 19 to 69 years with a mean age of 30.03 years ($SD = 10.19$). Children were recruited via parental consent letters that were sent to schools and summer schemes local to the university of the first author. All the adult participants in this study responded to an advertisement that was placed around the university campus and were compensated financially.

Materials and procedure

The materials and procedure were identical to those in Experiment 1 except that participants could select only one of two characters as feeling happier (see Fig. 1B).

Results

Initially, we examined participants' responses to the memory checks. The average numbers of errors made across the memory checks for the 5- and 6-year-olds, 7- and 8-year-olds, 9- to 11-year-olds, and adults were 0.89, 0.59, 0.15, and 0.40 errors, respectively. Inspection of individual data points revealed that no participants made 7 or more memory check errors, so no participants were excluded from the analyses.

Next, we investigated the emotion judgments made across the stories. As can be seen from Fig. 3, the vast majority of 9- to 11-year-olds and adults judged that the target character feels happier in both the counterfactual and temporal relief stories. A smaller majority of 5- and 6-year-olds and 7- and 8-year-olds also gave target answers across both story types. To analyze the data, we ran a mixed effects logistic regression using the *lme4* package in R (Bates, Maechler, Bolker, & Walker, 2015) to examine which variables predicted selection of the "target" character rather than the "non-target" character. Our full model included the fixed effects of age group, scenario, and relief type as well as the two-way interactions between age group and relief type and between relief type and scenario. The adult age group and counterfactual relief type were used as the reference categories. Participant ID was included as a random effect to control for the within-participant variance. The first step in reducing the full model was to remove the Scenario \times Relief Type interaction ($\Delta BIC = 21.5$) and the Age Group \times Relief Type interaction ($\Delta BIC = 13.2$). Next, the effect of scenario was removed ($\Delta BIC = 22.0$). The effect of relief type was retained because the BIC difference of 4.3 was considered too weak

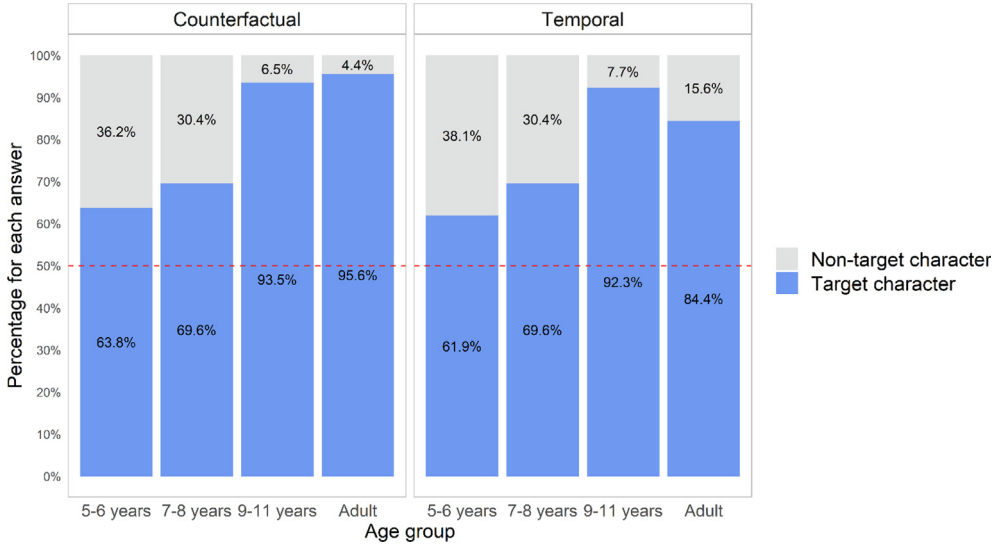


Fig. 3. Percentages of participants selecting “target character” and “non-target character” in Experiment 2 as a function of age group and story type. The dashed line shows the chance level for selecting each answer (50%).

Table 2

Results of mixed effects binomial logistic regression analyses for Experiments 2 and 3.

	β (SE)	Exp β	97.5% CI for Exp β
Experiment 2			
Intercept	3.73 (0.64)***	41.55	[11.86, 145.58]
Age group			
5–6 years	–2.68 (0.76)***	0.07	[0.02, 0.30]
7– 8 years	–1.91 (0.77)*	0.15	[0.03, 0.67]
9–11 years	0.87 (0.78)	2.40	[0.52, 11.08]
Relief type			
Temporal	–0.37 (0.23)	0.69	[0.44, 1.09]
Experiment 3			
Intercept	4.11 (0.83)***	61.17	[11.93, 313.52]
Age group			
5–6 years	–4.95 (1.01)***	0.01	[0.00, 0.05]
Relief type			
Temporal	–1.14 (0.66)	0.32	[0.09, 1.15]
Age Group \times Relief Type	1.74 (0.78)*	5.74	[1.24, 26.63]

Note. The adult group is the reference category for the age groups in Experiment 2. In Experiment 3, the reference category is the 8- and 9-year-old group. For Experiment 2, marginal $R^2 = .20$, conditional $R^2 = .70$, and ICC = .63. For Experiment 3, marginal $R^2 = .33$, conditional $R^2 = .71$, and ICC = .59. Marginal R^2 refers to the estimated variance explained by inclusion of fixed effects only, and conditional R^2 provides estimated variance explained by the entire model. Intraclass correlation (ICC) is an estimation of how much of the variance can be accounted for by a random effect.

* $p < .05$.
 *** $p < .001$.

to warrant omission. Finally, the effect of age group was retained because the BIC comparison was negative ($\Delta BIC = -12.6$).

Table 2 reports the findings of the analysis for the final model. The adults were more likely to make target judgments when compared with the 7- and 8-year-olds ($p = .013$) and the 5- and 6-year-olds ($p < .001$). However, the model revealed that the adults were no more likely to make target judgments

than the 9- to 11-year-olds ($p = .263$). When the 9- to 11-year-olds were set as the reference category for age group, the model revealed that the 9- to 11-year-olds were more likely to make target judgments than the 7- and 8-year-olds ($b = -2.78$, $SE = 0.73$, $p < .001$, $OR = 0.06$, 97.5% CI [0.01, 0.26]) and 5- and 6-year-olds ($b = -3.55$, $SE = 0.73$, $p < .001$, $OR = 0.03$, 97.5% CI [0.01, 0.12]). With the 7- and 8-year-olds as the reference category, the model did not reveal any significant differences between the 7- and 8-year-olds and 5- and 6-year-olds ($b = -0.77$, $SE = 0.67$, $p = .252$, $OR = 0.46$, 97.5% CI [0.12, 1.73]). Importantly, our final model did not indicate relief type to be a significant predictor for selecting the target judgment ($p = .112$).

Following the main analysis, we used binomial sign tests and Bayesian equivalents to compare proportions of target judgments in counterfactual and temporal relief story types with chance performance (i.e., 50%) for each age group. The proportions of target judgments in the adult group were above what would be expected by chance levels for both counterfactual ($p < .001$, $BF_{10} = 5.32e^{18}$) and temporal ($p < .001$, $BF_{10} = 1.51e^9$) story types. A similar pattern of results was observed in the 9- to 11-year-olds for the counterfactual ($p < .001$, $BF_{10} = 6.18e^{29}$) and temporal ($p < .001$, $BF_{10} = 1.28e^{28}$) story types. In addition, the 7- and 8-year-olds selected target characters above chance in the counterfactual ($p < .001$, $BF_{10} = 358.1$) and temporal ($p < .001$, $BF_{10} = 358.01$) versions. Finally, the frequentist analyses revealed that the proportions of target judgments in the 5- and 6-year-olds were above chance levels for the counterfactual ($p = .006$) and temporal ($p < .019$) story types. According to the criteria of Lee and Wagenmakers (2014), the Bayesian equivalents revealed that there was moderate evidence for the proportion of target judgments being different from chance in the counterfactual story types ($BF_{10} = 6.75$), and there was anecdotal evidence for a difference from chance in the temporal story types ($BF_{10} = 2.38$).

Discussion

After removing the option to judge that both characters felt the same, we found that children as young as 7 and 8 years were above chance at selecting the target character, whereas 9- to 11-year-olds made adult-like judgments. Although the modal response in the 5- and 6-year-old group was “target,” results of Bayesian analyses suggest that there was no strong evidence that this group made target judgments above chance levels in the counterfactual and temporal versions. Overall, these results are strikingly different from those of Experiment 1, where children up to 10 years of age, when presented with the same stories, typically indicated that the two characters would feel the same. Taken together, the results of Experiments 1 and 2 suggest that children up to 10 years of age have difficulty in *spontaneously* accessing an understanding of relief (i.e., they have difficulty in attributing relief to others without explicit prompts). However, when prompted to focus on emotional differences between two characters, 7- and 8-year-olds, as well as some 5- and 6-year-olds, begin to demonstrate a fledgling understanding of both types of relief that develops until adult levels of understanding emerge at around 9 years of age. This is the first empirical evidence identifying an age at which children can begin to understand relief (of either type) in others. As in Experiment 1, judgments did not differ between the relief types for any age group.

Experiment 3

In our third experiment, we sought to replicate our finding that the general tendency to make relief attributions increases from 5 to 10 years of age. Therefore, we used the same stories as in Experiment 2 and compared performance of a group of 5- and 6-year-olds with that of a group of 8- and 9-year-olds. In addition, we wanted to check that the younger children who were less likely to give target answers were not doing so due to memory problems. Although there was little evidence in Experiments 1 and 2 to suggest that young children gave different judgments due to memory problems, we wanted to eliminate this as a possibility. Accordingly, we added two additional memory checks to each story to ensure that children could understand and recall that the characters either avoided or endured an event that was negative for one of them and were now engaging in a task that they both enjoy.

Method

Participants

A total of 59 children (47.5% female) took part in this experiment. The 5- and 6-year-olds consisted of 29 participants (55.2% female) aged 64 to 80 months with a mean age of 69.10 months ($SD = 3.52$). The 8- and 9-year-olds consisted of 30 participants (40.0% female) aged 100 to 114 months with a mean age of 106.03 months ($SD = 4.24$).

Materials and procedure

The materials and procedure were identical to those in Experiment 2 except for two additional memory checks per story. These additional checks were made directly before the emotion judgment in each story. In the counterfactual versions of the stories, the first question checked whether participants could remember what *could* have happened to the characters but *did not*. In the temporal versions, the first memory question checked whether participants could recall what the characters *had been* doing. For all versions of the stories, the second memory check asked participants what the characters were doing *now*. This ensured that the children were able to remember that participants were now engaged in the pleasant activity that should induce relief in the target characters (see [supplementary material](#) for exact wording). If participants gave an incorrect answer to these additional checks, they were asked to listen to the relevant part of the story and try again. If they answered the memory check incorrectly a second time, their judgment for that story was removed from further analyses. Furthermore, participants who made 5 or more errors across the 12 additional memory checks (i.e., more than 33.3% of the questions answered incorrectly) were excluded entirely from the analyses. Note that participants were still required to answer the memory questions regarding characters' attitudes that had been included in Experiments 1 and 2. Therefore, in total, participants responded to 18 checks regarding the characters' attitudes and 12 additional memory checks concerning their understanding of the counterfactual or temporal nature of the stories. The experimental session lasted approximately 20 min.

Results

First, we examined responses to the memory checks concerning the characters' preferences that were also used in Experiments 1 and 2. Inspection of individual data points revealed that 4 5- and 6-year-olds made 7 or more errors in the preference checks and, as in Experiments 1 and 2, were excluded from subsequent analysis. Although the remaining 5- and 6-year-olds made more errors on average (1.84 errors on average) than the 8- and 9-year-olds (0.47 errors on average), this difference was nonsignificant ($U = 411, p = .451$). Next, we examined responses to the additional memory checks concerning the temporal or counterfactual nature of the stories. The average number of errors in these additional checks was minimal for both the 5- and 6-year-olds (0.56 errors on average) and 8- and 9-year-olds (0.27 errors on average). No participants were excluded on the basis of making 5 or more errors in these additional memory checks.

Following this, we investigated the emotion judgments made at the end of the stories. It can be seen from [Fig. 4](#) that the 8- and 9-year-olds made target judgments the vast majority of the time in both counterfactual (91.1%) and temporal (84.4%) relief trials. By contrast, the 5- and 6-year-olds gave fewer target answers on average in both the counterfactual (36.0%) and temporal (45.3%) relief story types. As in Experiment 2, we built a full mixed effects binary logistic regression model using *lme4* and included the fixed effects of age group, scenario, and relief type as well as the two-way interactions between age group and relief type and between relief type and scenario. Participant ID was included as a random effect. The baseline categories for age group and relief type were 8- and 9-year-olds and counterfactual relief, respectively. The first step in reducing the full model was to remove the Age Group \times Scenario interaction ($\Delta BIC = 27.6$). The Age Group \times Relief Type interaction was retained because the BIC comparison was negative ($\Delta BIC = -0.23$). Following this, the effect of scenario was removed ($\Delta BIC = 16.64$). Finally, because the BIC comparisons supported inclusion of the Age Group \times Relief Type interaction, it was necessary to include the lower-order effects of both age group and relief type in the final model.

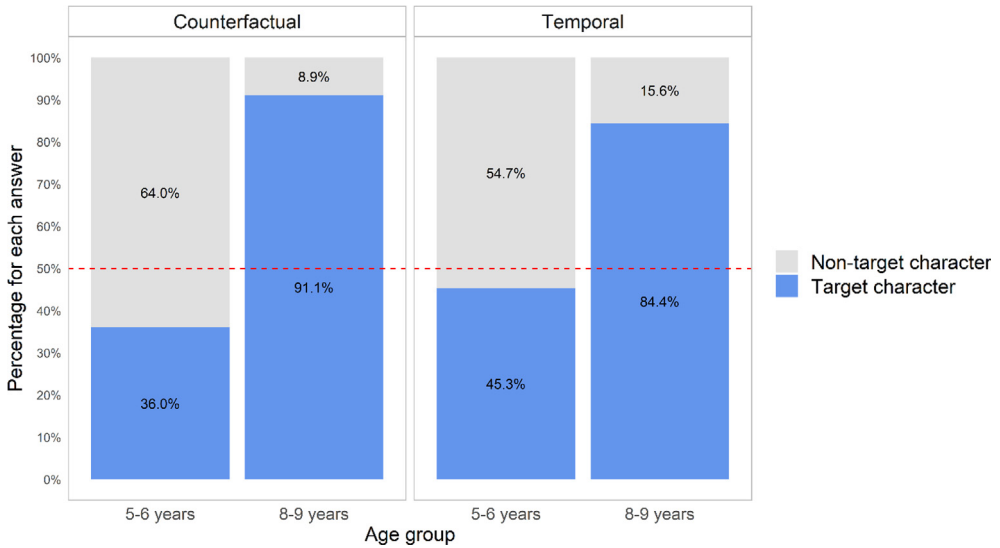


Fig. 4. Percentages of participants selecting “target character” and “non-target character” in Experiment 3 as a function of age group and story type. The dashed line shows the chance level for selecting each answer (50%).

As can be seen in Table 2, age group was a significant predictor of selecting the target option when comparing the 8- and 9-year-olds with the 5- and 6-year-olds ($p < .001$). However, the final model did not reveal relief type to be a significant predictor of making target judgments ($p = .081$). Although a significant interaction was observed between age group and relief type ($p = .026$), a series of pairwise comparisons on target judgments with Tukey-adjusted p values, using the *emmeans* package in R (Lenth, 2020), did not reveal significant differences between the relief types for 5- and 6-year-olds ($b = -3.81$, $SE = 0.42$, $p = .476$, $OR = 0.55$) or 8- and 9-year-olds ($b = 1.14$, $SE = 0.65$, $p = .030$, $OR = 3.13$) (see supplementary material for report of all comparisons).

Finally, we compared proportions of target selections with chance with binomial sign tests and Bayesian equivalents. The analyses indicated that the proportions of target judgments made by the 8- and 9-year-olds were above expected chance levels in both the counterfactual ($p < .001$, $BF_{10} = 1.76e^{14}$) and temporal ($p < .001$, $BF_{10} = 1.51e^9$) versions of the stories. By contrast, our analyses revealed that the proportions of target judgments made by the 5- and 6-year-olds in the temporal stories were no different from chance ($p < .489$, $BF_{10} = 0.20$). Although the frequentist binomial sign test revealed that the proportions of target judgments in the 5- and 6-year-olds were just lower than expected by chance for the counterfactual stories ($p = .02$), Bayesian equivalents suggest that there was only anecdotal evidence to suggest the 5- and 6-year-olds were lower than what was expected by chance in those stories ($BF_{10} = 2.71$).

Discussion

In Experiment 3, we replicated the finding that children’s understanding of relief develops from 5 to 10 years of age. In particular, we found that a group of 8- and 9-year-olds was more likely to judge that the target character feels happier than a group of 5- and 6-year-olds. Performance in the memory checks concerning the temporal and counterfactual nature of the stories was near perfect for both age

groups. As in the previous experiments, judgments did not differ between the two relief types for both age groups.

Unexpectedly, the 5- and 6-year-olds in this experiment gave fewer target judgments across the stories (40.7%) than the 5- and 6-year-olds in Experiment 2 (62.9%).⁸ Indeed, the frequentist analyses suggest that the proportion of 5- and 6-year-olds' target judgments was less than expected by chance in the counterfactual stories. However, caution is warranted in interpreting this as evidence that the 5- and 6-year-olds were better able to understand relief in the temporal versions than in the counterfactual versions of the stories given that the Bayesian comparisons only indicated anecdotal evidence that they were different from chance. Furthermore, our main analyses did not reveal relief type to be a significant predictor of target judgments, nor did it indicate an Age Group \times Relief Type interaction, so there was no compelling evidence for children in either age group performing better in one version of the stories than the other.

There are at least two possible explanations for the discrepancy between 5- and 6-year-olds in Experiment 2 and those in Experiment 3. The first is that the 5- and 6-year-olds in Experiment 3 were on average 4 months younger than those in Experiment 2. Second, we suspect that the inclusion of two extra memory checks per story may have served to make the overall task more onerous and cognitively demanding for the younger participants. Indeed, participants in Experiment 3 were required to answer a total of 18 memory checks regarding the characters' attitudes and 12 further memory checks concerning their understanding of the counterfactual or temporal nature of the stories in addition to the test questions themselves. The addition of these extra memory checks made the session considerably longer and might have placed extra demands on the younger participants' attention and working memory. Further support for this claim comes from the fact that the 5- and 6-year-olds in Experiment 3 made more than twice as many errors on average in the attitude memory checks (1.84 errors on average) than those in Experiment 2 (0.89 errors on average). In our fourth study, we explored the possibility that the younger participants in Experiment 3 failed to select target characters due to high demands on their working memory, and we also looked more closely at the specific age at which children may succeed on our task.

Experiment 4

The results of Experiment 3 suggest that increasing the length and cognitive demands of the task might have served to affect participants' emotion judgments at the end of the stories. It is possible that reducing the working memory demands of the vignettes could further facilitate children's ability to attribute relief to others. In Experiment 4, we used stories similar to those in the previous experiments except that we decided to remove the stimuli both characters really liked from each story. Therefore, participants were only required to mentally represent characters' attitudes toward one stimulus (i.e., the stimulus the two characters felt differently about) instead of multiple stimuli. We originally included a positive stimulus because in the counterfactual stories the inclusion of a positive stimulus allowed for a clear contrast between the positive outcome that did occur and a negative outcome that was avoided; temporal stories were then matched to counterfactual stories in this respect. However, it should be possible to infer counterfactual relief simply on the basis of a character avoiding a negative outcome, with the necessary contrast between the non-occurrence of the negative outcome (actual scenario) versus the occurrence of that negative outcome (counterfactual scenario).

This alteration meant that at the end of the stories, there was no positive stimulus to replace the aversive stimulus. For example, in the medicine story, Sally and Anne simply avoided or endured drinking strawberry medicine for a while but did not receive chocolate medicine afterward as in the previous experiments. It is possible that in the previous experiments the positive outcome at the end of the stories served to overshadow any previous or avoided negative events that the characters may have experienced. In other words, the positive end state of the stories might have made the

⁸ In both experiments, point-biserial correlations indicated that children in the 5- and 6-year-old groups who were older in months were more likely to make target judgments (Experiment 2: $r_{pb} = .19$, 97.5% CI [.035, .33], $p = .006$; Experiment 3: $r_{pb} = .22$, 97.5% CI [.037, .39], $p = .007$). See supplementary material for full report of correlation analyses.

relief in the target character less obvious, resulting in participants not reliably selecting the target character. Indeed, there is some evidence to suggest that children are less likely to think counterfactually following events that are positive than following events that are negative (German, 1999; Gleicher et al., 1990; Guttentag & Ferrell, 2004). This suggests a further reason why removing the positive outcome might affect performance; removing this outcome might increase the likelihood that participants focus on the negative counterfactual or factual past event.

In addition to this methodological change, we decided to use finer-grained age groups to pinpoint the age at which children can first understand relief in others more accurately and also to address the concern that the contrasting results of Experiments 2 and 3 may have been due to age differences between the groups. We included a younger group of 4-year-olds to explore whether there was any evidence of relief understanding before 5 and 6 years of age. Due to the COVID-19 pandemic, this experiment was conducted online. In all other respects, the procedure was identical to the previous experiments.

Method

Participants

A total of 116 children aged 4 to 6 years (65 female) participated in this experiment. Children were divided into three groups on the basis of chronological age. The youngest group of 4-year-olds consisted of 34 children (44.1% female) aged 48 to 59 months with a mean age of 54.15 months ($SD = 3.33$). The 5-year-olds consisted of 43 children (53.5% female) aged 60 to 71 months with a mean age of 65.16 months ($SD = 3.11$). The 6-year-olds consisted of 39 children (69.2% female) aged 72 to 83 months with a mean age of 77.44 months ($SD = 2.95$). Advertisements for the study were posted online, and parents registered interest for their children to take part by contacting the research team via Qualtrics, an online survey platform.

Materials

The stories used in this experiment were similar to those used in the previous experiments except that in each story we removed the stimulus that both characters liked equally. Instead, participants were only informed about the stimulus that the two characters felt differently about. Therefore, in the counterfactual versions of the stories the characters simply avoided the stimulus they felt differently about, whereas in the temporal versions the characters simply endured the stimulus they felt differently about for a while and then this came to an end. Because only one stimulus was introduced, there were only 2 memory checks per story (12 memory checks across all the stories) and the overall length of the stories was shorter than that in previous experiments (see [supplementary material](#) for exact text and images of the updated stories). In the final screens, the buttons depicted the characters and their preferences toward only one stimulus (see [Fig. 1C](#)).

Procedure

Parents who registered interest in the study were invited to join a video call with their children via Microsoft Teams at a time that suited them. At the beginning of the session, parents were advised to turn on their webcams and to enter full screen mode on their device so that the stories were as large as possible for every participant. Using materials from guidelines for conducting moderated developmental research online (Social Learning Lab, 2020), parents and children were given instructions about the study. Child participants were informed that they were going to see some short stories on their screen and would be asked some questions about how characters are feeling. Parents were encouraged to sit behind their children during the stories and not to provide any feedback. Following this, the researcher shared the OpenSesame screen with the child participants and ensured that they could see the images and hear the audio presented in the program.

Subsequently, the researcher trained participants to understand the attitude symbols and went through the practice story used in the previous experiments. For the practice story, participants were

asked to give their answers verbally and also to point at the relevant button. Then, parents confirmed that participants were pointing at the same button that they had verbally indicated. Following this, participants listened to and made judgments in response to the six relief vignettes. When the question “Who feels happier now?” was asked at the end of each story, the researcher read out each of the characters’ names and circled the corresponding buttons on the screen to make these options clear for participants. The vast majority of participants gave their answers verbally, but participants who were too shy to speak were asked to point at one of the characters on their screen. The researcher then circled the answer these participants had indicated and asked them to confirm that this was the button they wanted to select. After participants made judgments in the six stories, families were thanked for their time and provided with an opportunity to give feedback on their study experience. Participants who made 5 or more errors across the 12 memory checks (i.e., answered more than 33.3% of the questions incorrectly) were excluded from the analyses. Including the online introductions, sessions lasted approximately 20 min.

Results

First, we examined responses to the memory checks. The average numbers of errors made across the memory checks by the 4-year-olds, 5-year-olds, and 6-year-olds were 0.42, 0.26, and 0.11 errors, respectively. No participants were excluded on the basis of making errors.

Next, we investigated the emotion judgments made at the end of the stories. From Fig. 5, it can be seen that the modal response of 6-year-olds was the target character in both the counterfactual (79.5%) and temporal (74.4%) story types. A smaller majority of 5-year-olds gave target responses in the counterfactual stories (65.9%), whereas just over half of the responses from this age group were target answers in the temporal stories (56.1%). By contrast, fewer than half the responses in the 4-year-old group were target answers in both the counterfactual (45.5%) and temporal (44.4%) story types. As in Experiments 2 and 3, we ran a mixed effects logistic regression in R to examine the variables that predicted making target judgments over non-target judgments. The full model consisted of the fixed effects of age group, scenario, and relief type as well as the two-way interactions between age group and relief type and between relief type and scenario. The baseline categories for age group, scenario, and relief type were the 6-year-olds, the housework scenario, and counterfactual relief, respectively. Participant ID was included as a random effect. In the first step, BIC comparisons strongly suggested removing the two-way interactions (Δ BICs: Age Group \times Scenario = 54.9, Age Group \times Relief Type = 10.9). Following this, the fixed effects of scenario (Δ BIC = 8.99) and relief type (Δ BIC = 1.57) were retained because the BIC differences were not strong enough to warrant removal. Finally, age group was retained because the BIC comparison was negative (Δ BIC = -1.07).

As can be seen in Table 3, the model revealed that the 6-year-olds were more likely to make target judgments than the 4-year-olds ($p < .001$) and, to a lesser extent, the 5-year-olds ($p = .040$). Notably, if 5-year-olds are set as the baseline category for age group, the model suggests that 5-year-olds were no different than 4-year-olds at making target judgments ($b = -1.42$, $SE = 0.76$, $p = .064$, OR = 0.24, 97.5% CI [0.05, 1.08]). The final model also revealed relief type to be a significant predictor when comparing counterfactual relief stories with temporal relief stories ($p = .028$), suggesting that target judgments were overall more frequent in counterfactual relief stories. Unexpectedly, the model also revealed scenario to be a significant predictor of target judgments such that more target judgments were found for the scenarios about an unpleasant car journey and doing housework than for the other scenarios (see [supplementary material](#) for a full report of these analyses). Importantly, scenario was not involved in a significant interaction with any other variable.

Finally, we compared the proportion of target selections with chance using binomial sign tests and Bayesian equivalents. The 6-year-olds were above chance in both the counterfactual ($p < .001$, $BF_{10} = 2.55e^8$) and temporal ($p < .001$, $BF_{10} = 1.98e^5$) versions of the stories. The 5-year-olds were also above chance in the counterfactual versions of the stories ($p < .001$, $BF_{10} = 57.51$) but were at chance in the temporal versions ($p = .207$, $BF_{10} = 0.28$). The 4-year-olds did not differ from chance in either the counterfactual ($p = .422$, $BF_{10} = 0.19$) or temporal ($p = .315$, $BF_{10} = 0.23$) versions of the stories.

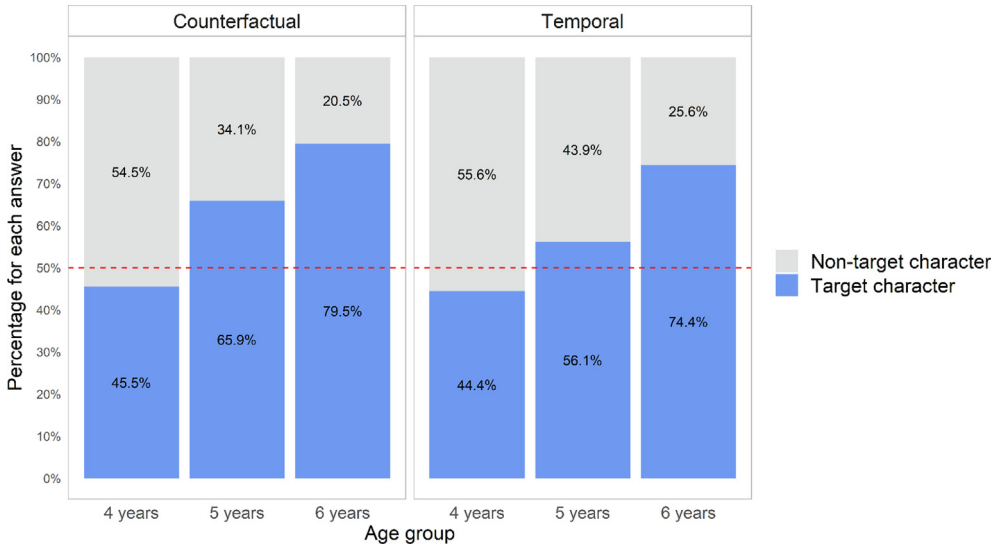


Fig. 5. Percentages of participants selecting “target character” and “non-target character” in Experiment 4 as a function of age group and story type. The dashed line shows the chance level for selecting each answer (50%).

Table 3

Results of mixed effects binomial logistic regression analyses for Experiment 4.

	β (SE)	Exp β	97.5% CI for Exp β
Experiment 4			
Intercept	3.86 (0.7) ***	47.38	[12.02, 186.78]
Age group			
4 years	-3.00 (0.82) ***	0.05	[0.01, 0.25]
5 years	-1.59 (0.77) *	0.20	[0.04, 0.93]
Relief type			
Temporal	-0.54 (0.24) *	0.58	[0.36, 0.94]
Scenario			
Housework	-0.73 (0.43)	0.48	[0.21, 1.12]
Medicine	-1.56 (0.44) ***	0.21	[0.09, 0.48]
Party	-1.66 (0.44) ***	0.19	[0.08, 0.45]
Singing	-0.90 (0.44) *	0.41	[0.17, 0.96]
Games	-1.57 (0.44) ***	0.21	[0.09, 0.49]

Note. The 6-year-old group is the reference category for age group. Counterfactual relief is the reference category for relief type. Journey is the reference category for scenario. Marginal $R^2 = .14$, conditional $R^2 = .76$, and intraclass correlation (ICC) = .72.

* $p < .05$.
 *** $p < .001$.

Discussion

In Experiment 4, we simplified the vignettes so that participants were only required to mentally represent characters’ attitudes toward one stimulus. A greater majority of 6-year-olds (>70%) selected the target character in both the counterfactual and temporal story types than the 5- and 6-year-old groups in previous experiments, potentially suggesting that the simplified stories did indeed facilitate young children’s ability to attribute relief to others. Our analysis also revealed that the 6-year-olds were significantly more likely to make target judgments when compared with the 5-year-old and 4-year-old groups. Interestingly, this is the first experiment in which the final model indicated a main

effect of relief type, suggesting that participants were overall more likely to make target judgments in the counterfactual versions of the stories than in the temporal versions. Moreover, our chance comparisons revealed that the 5-year-olds made target judgments above what was expected by chance in the counterfactual versions of the stories but not in the temporal relief stories. By contrast, performance in the 4-year-old group did not differ from chance levels in either story type. Despite this, our final model did not indicate an interaction between age group and relief type, so any apparent differences should be treated cautiously.

Unexpectedly, our final model further revealed a main effect of scenario type when comparing scenarios involving an unpleasant car journey and an unpleasant period spent tidying up with the other scenarios. This is the first of our experiments to reveal a main effect of scenario on judgments made. To the extent that this effect is reliable, one could speculate that it could be driven in part by the fact that the children in our sample might have had more real-life experiences with car journeys and cleaning up than with the events described in the rest of our scenarios. Their familiarity with these events may have scaffolded the ability of the younger participants in particular to attribute emotional responses to others at the end of or avoidance of experiences that they had gone through themselves.

In sum, these findings suggest that, at least when given simplified vignettes, children begin to demonstrate an ability to attribute relief to others by 6 years of age. Unlike the previous experiment, overall there were more target judgments made in the counterfactual versions of these stories than in the temporal versions. Although this appears to be particularly pronounced in the 5-year-olds, our analyses did not reveal an Age \times Relief Type interaction, so caution is warranted in interpreting this as a developmental delay between understanding the two types of relief. The significant main effect suggests that at least some children found it easier to make attributions of relief in counterfactual instances than in temporal instances of relief.

General discussion

This study is the first to investigate the developmental profile of children's understanding of temporal relief and to directly compare children's understanding of counterfactual instances of relief with their understanding of temporal instances of relief. In Experiment 1, children up to 10 years of age, unlike adults, typically judged that two characters felt the same despite understanding that only one character strongly disliked the event they had just avoided or endured. However, when we encouraged children to make a comparison between the two characters in Experiments 2 to 4, even some 5- and 6-year-olds demonstrated a fledgling ability to understand the two types of relief in others. Although performance of 5- and 6-year-olds was subsequently worse in Experiment 3 than in Experiment 2, we suspect that this is due to higher working memory demands from additional memory checks. In Experiment 4, we used simplified stories and found that a clear majority of 6-year-olds were likely to attribute relief appropriately to others, whereas 5-year-olds were only above chance at making target judgments in the counterfactual versions of the stories (caution is warranted, however, in interpreting this effect as evidence for a developmental delay between the two types of relief). There was no evidence of an understanding of relief in 4-year-olds.

Overall, as we now discuss, these results indicate that young children may have difficulty in attributing relief to characters in our task under circumstances in which (a) they are not clearly prompted to contrast the emotional reactions of characters, (b) the working memory demands of the task are relatively high, and (c) characters are explicitly described as having positive experiences that may distract focus from the relevant negative experiences that have been endured or avoided. Put together, our findings suggest that children's understanding of relief in others might not be an all-or-nothing ability; rather, children as young as 6 years show some understanding of this emotion, but with development they can evidence this understanding more spontaneously (i.e., with less prompting from adults) and in contexts where they need to keep track of more pieces of information. Although we did not find evidence for a difference in the developmental patterns of children's understanding of the two types of relief, Experiment 4 suggests that overall, at least under some circumstances, young children may be better able to make attributions of counterfactual relief than of temporal relief.

Understanding of relief in others

The judgments made by participants in Experiment 1 mirror the pattern of responses in [Guttentag and Ferrell's \(2004\)](#) stories of counterfactual relief. Those authors found that 7-year-olds, unlike adults, typically judged two characters to feel the same upon obtaining a positive outcome despite having made decisions that differed in their mutability, and they concluded that children of this age did not understand relief. The results of Experiment 1 extend these findings to show that children up to 10 years of age (but not adults) also typically judge two characters to feel the same in more basic scenarios of relief, where only one character has grounds to feel relieved because he or she dislike the previously experienced or avoided event. One explanation as to why children did not judge the target character as feeling happier in these stories is that children and adults alike are less likely to entertain alternatives following positive outcomes than following negative ones ([Byrne, 2016](#); [German, 1999](#); [Gleicher et al., 1990](#); [Landman, 1987](#)). Indeed, 7-year-olds were capable of entertaining counterfactuals in [Guttentag and Ferrell's \(2004\)](#) stories with negative outcomes. Interestingly, a notable proportion of adults judged both characters to feel the same in our first experiment (25%) and in [Guttentag and Ferrell's](#) relief stories (32%). This suggests that even adults might not always spontaneously attribute relief to others, even when there are grounds to do so, if characters are being described as currently undergoing a positive experience. Given that children require stronger triggers to think about alternative events than adults (e.g., [Ferrell et al., 2009](#)), the positive outcomes in our stories might not have sufficiently encouraged children to spontaneously consider the previous factual or counterfactual events necessary to attribute relief to the characters.

Another possible (and not necessarily competing) explanation of children's difficulties may have been that they interpreted the test question to be "Who feels happy now?" rather than "Who feels happier now?" In Experiment 2, where we removed the "both" option, we found that 7- and 8-year-olds were above chance at selecting the target character, and by 9 to 11 years of age children were no different from adults. Although the majority of responses given by 5- and 6-year-olds were for the target, these were not conclusively above what was expected by chance. These results suggest that young children may be capable of attributing relief to others in circumstances where they are prompted to think about the emotional differences between two characters and that the tendency to make these adult-like judgments increases with age. This provides the first indication of when children begin to understand counterfactual relief in others, adding to a growing literature on the development of counterfactual emotions (e.g., [Weisberg and Beck, 2010](#)). These results also provide the first evidence regarding the developmental profile of children's understanding of temporal relief. The finding that children can attribute temporal relief to others by 7 or 8 years of age adds to the body of research suggesting that young children are capable of taking past events into account when making judgments about how people feel at the current time rather than merely focusing on what is currently happening (see [Lagattuta, 2014](#), for a review).

In Experiment 3, we replicated the finding that older children are capable of attributing relief to others when they need to compare the two characters and showed that this ability improves from 5 to 8 years of age. Notably, however, the 5- and 6-year-olds made fewer target selections than in Experiment 2, possibly because of the age profile of the sample or because additional memory checks imposed higher attention and working memory demands, which in turn impeded children's ability to attribute relief to the characters. In Experiment 4, we removed the positive outcome in an attempt to reduce the processing demands of the task and potentially help to focus attention on the relevant past (or counterfactual) events, and we also used narrower age bands in an attempt to pinpoint the age at which children could succeed at the task. When participants were only required to mentally represent characters' feelings toward one event, the clear majority of 6-year-olds were likely to give target judgments, 4-year-olds were not successful, and 5-year-olds' performance was intermediate, with above-chance performance on one type of story but not on the other. It is also possible that the removal of positive outcomes in Experiment 4 may have further scaffolded children's ability to generate counterfactuals or focus on the past given that previous developmental studies suggest that children are less likely to entertain alternatives when the outcome is positive (e.g., [German, 1999](#)).

Overall, these results suggest that although children up to 10 years of age struggle to spontaneously attribute relief to others, a fledgling understanding of relief begins to emerge at 5 to 6 years of age,

considerably earlier than suggested in previous developmental research (Guttentag & Ferrell, 2004; Weisberg & Beck, 2010). Our findings suggest that the tendency to make these attributions increases with age and generalizes into less scaffolded contexts with development into adulthood. More specifically, younger children were more likely to demonstrate an understanding of relief in Experiment 4, where the materials imposed fewer working memory demands, than in Experiments 2 and 3, where participants were required to mentally represent two characters' preferences toward multiple stimuli. Thus, the results of our current experiments suggest that 6-year-olds typically do possess an understanding of relief that is similar to that of older children and adults. However, younger children can only demonstrate such an understanding of relief when there are fewer demands on their working memory, whereas older children and adults are able to do so even in more cognitively demanding contexts. This is consistent with research into counterfactual emotions, which suggests that these abilities do not emerge in an all-or-none fashion (Ferrell et al., 2009), but rather the tendency to make these attributions increases with age and interacts with the triggers and cognitive demands present in any given situation. This is also consistent with the broader developmental literature, which suggests that the acquisition of complex emotion concepts does not happen abruptly during childhood, but rather children's understanding of emotions becomes more sophisticated and differentiated throughout childhood (e.g., Graham, 1988; Russell & Paris, 1994). It is worth noting that these results were observed within a sample of predominantly White participants from lower- to middle-class socioeconomic backgrounds in the United Kingdom. Although theoretically there is no salient reason why children in other cultures should exhibit qualitatively different developmental profiles with regard to their understanding of relief, future work should seek to generalize the current findings to other socio-cultural groups.⁹

From a functional perspective, children who possess a sophisticated understanding of temporal relief will be better able to understand how others feel at the offset of negative events. Knowing how others feel in specific scenarios is an important sociocognitive skill predictive of improved social skills, academic performance, and cognitive competence (e.g., Denham et al., 2003; Garner & Waajid, 2012; Trentacosta & Izard, 2007). An adept understanding of counterfactual relief could also facilitate the use of effective consoling strategies such as employing downward counterfactuals to engender relief in others and help them to feel better about their current state of affairs (see Payir & Guttentag, 2016).

Understanding counterfactuals or making simple comparisons?

So far, we have assumed that success in the counterfactual versions of our stories involves appreciating the role that an agent's awareness of a counterfactual (e.g., of not having needed to take unpleasant strawberry medicine) plays in determining the agent's emotional state. This interpretation of the task demands is the standard interpretation of self-report tasks designed to examine children's and adults' own experiences of counterfactual emotions such as regret and relief. In such tasks (e.g., Coricelli et al., 2005; Weisberg & Beck, 2010, 2012), it is assumed that participants experience the relevant counterfactual emotion if their emotion ratings are affected not just by the actual outcome but also by information about the counterfactual outcome. Thus, analogously, we have assumed that children demonstrate an understanding of counterfactual relief if they reason that characters' emotional states are affected not just by an actual outcome but also by receiving information about a counterfactual outcome. However, we are also aware that there is ongoing debate in the developmental literature about whether existing tasks genuinely measure counterfactual emotions and, more broadly, about whether children's success on some counterfactual reasoning tasks might be underpinned by

⁹ There may be important cross-cultural differences in the situations where relief occurs in children's everyday lives. For example, Harris, Olthof, Terwogt, and Hardman (1987) explored the development of situational knowledge about emotions, including relief, in children from the United Kingdom, the Netherlands, and a remote village in Eastern Nepal. They found that Nepalese children tended to describe emotions in the context of agricultural labor, rare foods, and poverty, whereas their Dutch and English peers tended to provide examples of emotions in the context of play, pets, and education. Future work could investigate the various contexts that are likely to elicit relief in children across cultures and whether these are accompanied by different patterns of developing competence.

more simple types of reasoning that do not involve representing counterfactuals per se (e.g., Kominsky et al., 2021; Leahy, Rafetseder, & Perner, 2014; Nyhout, Henke, & Ganea, 2019; Rafetseder & Perner, 2012). Conceivably, it might be possible to argue that success in the counterfactual versions of our stories does not rely on representing the alternative outcome counterfactually. Rather, target judgments may have been based on actual outcomes only, for example, that a character received his or her preferred medicine and avoided the disliked medicine. On this line of argument, it would be assumed that the disliked medicine simply serves as a “standard of comparison” (rather than a counterfactual possibility) against which the character is assumed to compare the actual outcome (see Doan et al., 2020). We acknowledge that our interpretation of the counterfactual stories as involving mature counterfactual reasoning could potentially be challenged by a theorist who holds this alternative interpretation of relief tasks in both the child literature and adult literature, counter to the consensus position. This possibility is one that counterfactual researchers are beginning to engage with and could extend to include new studies of relief. Firmly establishing that our counterfactual stories involve “genuine” counterfactual reasoning will require a more complex events sequence (e.g., using overdetermined events; see McCormack, Ho, Gribben, O’Connor, & Hoerl, 2018; Rafetseder et al., 2013). We see the current findings as a necessary first step toward examining when children start to demonstrate an adult-like understanding of counterfactual relief.

Distinguishing between two types of relief

In regard to our primary question about the ontogeny of children’s understanding of the two types of relief, we did not find any compelling evidence across the four experiments that children’s understanding of temporal relief emerges before their understanding of counterfactual relief. In fact, in our final experiment, using simplified stories, we found that participants tended to give more target judgments in the counterfactual versions of the stories rather than the temporal ones. However, although our comparisons with chance revealed that the 5-year-olds performed better than expected by chance in the counterfactual versions of the stories but not in the temporal ones, our main analyses did not suggest an Age \times Relief Type interaction. Therefore, caution is warranted in interpreting this as a developmental lag between understanding the two types of relief. Rather, these results suggest that an understanding of both types of relief appears to emerge concurrently and that some children, in scaffolded contexts, tend to make more attributions of relief to others when they have avoided an unpleasant event than when an unpleasant event has ended for them (i.e., more attributions of counterfactual relief than of temporal relief).

One possible explanation for this last finding concerns the interpretation of the final question, “Who feels happier now?” In the temporal versions of the stories in Experiment 4, the 5-year-olds might have simply focused on the fact that one character had an experience that they disliked, whereas the other did not, rather than considering the fact that the disliked experience was over and done with for both characters. If this was the case, systematically selecting the non-target character would be the predicted response, albeit one that does not match older children’s and adults’ more complex inferences about the determinants of current emotional state. Inspection of the pattern of scores for the 5-year-olds indicated that whereas 3/3 was the most common score for temporal relief questions, about 30% of participants of this age scored 0/3 (see Fig. 2 in the [supplementary material](#)). This suggests that there may have been a sub-group of the younger participants who did not consider the temporal structure of the stories but rather focused solely on whether or not a character had a disliked experience. Similarly, McCloy and Strange (2009) found that children tend to base emotion judgments on the overall affective quality of outcomes before they integrate comparisons between actual outcomes and alternatives into their judgments.

Young children’s difficulties in inferring temporal relief suggests that there may be further developments in children’s ability to use information about past events to infer current emotions (Lagattuta, 2014). Previous research has shown that even 3-year-olds are capable of understanding why an individual in a positive situation may feel sad when thinking about a past negative event and that by 6 years of age children can understand why an individual will feel happier during a negative situation when cued about a positive past event (Lagattuta & Wellman, 2001). Understanding temporal instances of relief involves a different type of comparison that hinges specifically on grasping

that the ending of a negative event can (perhaps paradoxically to young children) trigger a positive emotion. Future work could examine children's ability to understand how others feel (either positive or negative) *immediately* after events are over and under what conditions children make adult-like judgments about such emotions spontaneously.

Apart from the discrepancy concerning above-chance performance in Experiment 4, there was little evidence to support the notion that counterfactual relief and temporal relief have separate developmental profiles despite our initial speculation that children may find it easier to understand temporal relief than counterfactual relief. Thus, our findings do not support the hypothesis that understanding the two types of relief relies on separate cognitive prerequisites.

Arguably, what underlies the ability to understand both types of relief is the capacity to represent others as holding and comparing two models of reality. Previous developmental studies seem to suggest that comparing reality with a counterfactually simulated event relies on more complex abilities than simply comparing two actual events that occur in sequence. In particular, it has been argued that real-world counterfactual comparisons require simulating an alternative event that is incompatible with the current reality and acknowledging that, at one point in the past, both the counterfactual alternative and the current outcome were possible (e.g., Beck et al., 2014). However, it could be argued that temporal instances of relief similarly require a comparison between two incompatible models of reality. An unpleasant event that has just occurred but is no longer occurring is by definition incongruous with the current state of affairs. In other words, both past and current events cannot be occurring at the same time. It is possible that to understand both types of relief, individuals are required to draw comparisons between different possible and incompatible models of reality and use this information to infer others' emotional states. This requirement could explain why an understanding of both types of relief appears at the same point in development.

Understanding versus experiencing relief

Importantly, our study only examined children's understanding of these two instances of relief. Measuring the experience of temporal relief in children is potentially difficult and raises methodological and ethical challenges because by definition it would require putting children in a situation where they themselves have an unpleasant experience that comes to an end. Nevertheless, it may be worthwhile trying to resolve these challenges because, given the higher cognitive demands of inferring the emotional states of others (e.g., Arsenio et al., 2006), it is very likely that children's ability to experience counterfactual and temporal relief emerges earlier than an ability to attribute these states to others (see Weisberg & Beck, 2010).

Moreover, it could be that there are in fact two distinct developmental patterns if we were to examine children's ability to experience temporal versus counterfactual relief. Preliminary evidence from Sweeny and Vohs (2012) suggests that counterfactual experiences of relief rely specifically on engaging in downward counterfactual comparisons, whereas Hoerl's (2015) account of relief suggests that temporal relief experiences may rely on the understanding that events that were once occurring are now in the past. Thus, it remains possible that firsthand experiences of counterfactual and temporal relief may require distinctive cognitive prerequisites and therefore may have distinct developmental trajectories. Alternatively, if children's experiences of the two types of relief emerge simultaneously, it would support the notion that both instances of relief rely on similar abilities such as representing and flexibly comparing multiple realities. To further explore the developmental profiles of these two types of relief, future studies should employ tasks that directly elicit instances of counterfactual and temporal relief and compare children's ability to experience the two types of relief.

Previous research on the counterfactual emotion of regret also suggests that the emergence of the ability to experience regret may result in other developmental changes in children (notably decision making; McCormack et al., 2020). At this time, we know nothing about whether experiencing different types of relief as well (which may potentially emerge concurrently or at different stages during development) is linked to other behavioral changes. Relatedly, it would be interesting to examine children's ability to anticipate counterfactual relief and temporal relief, the latter of which has been theorized to be involved in completing tasks that are potentially aversive but ultimately beneficial (Hoerl, 2015).

Summary and conclusion

This study provides the first positive evidence as to when children begin to understand the emotion of relief in others. Our results suggest that although 6-year-olds demonstrate a nascent ability to attribute relief to others, their general tendency to make these attributions in adult-like ways does not develop until 8 or 9 years of age. Moreover, even children up to 10 years of age may struggle to spontaneously attribute either temporal or counterfactual relief to others when their attention is not directed to the contrasting attitudes two characters may have toward a certain experience. Thus, as in other aspects of the development of emotion understanding, children's understanding of relief gradually becomes more sophisticated and spontaneous with development. Although there was little evidence to suggest that separate developmental profiles exist with respect to children's understanding of the two types of relief, there was an indication in our final experiment that some children find it easier to attribute counterfactual relief to others than to attribute temporal relief to them. However, further research is needed to compare children's ability to *experience* relief in these two distinct scenarios. Such research may shed light on whether these types of relief have distinct cognitive prerequisites or rely on similar processes such as the ability to mentally hold and flexibly compare multiple models of reality. This in turn may inform researchers on the viability of the distinction between temporal relief and counterfactual relief itself.

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Appendix A. Full text of stories used in Experiments 1 to 3

This appendix comprises the six different scenarios presented to participants in Experiments 1 to 3. Only in Experiment 1 were participants given the option to judge "Or do they both feel the same?" See the online supplementary material for the images alongside the narration for all the stories.

Scenario A: Medicine

Introduction to characters

Sally and Anne are friends. Sometimes they like the same foods, and sometimes they don't like the same foods. Sally and Anne both love chocolate. But Sally thinks strawberries taste disgusting, while Anne thinks strawberries taste just all right.

Counterfactual version

One day Sally and Anne are sick. So they go to the doctor's to get some medicine! The doctor goes to the medicine cupboard. But the doctor cannot find any strawberry medicine. The doctor says, "I was going to give you strawberry medicine but we ran out. So here is some chocolate medicine instead!".

Temporal version

Sally and Anne are sick. They are drinking strawberry medicine first to make them better, but the next time they go to the doctor's they will get chocolate medicine! One day, they go to the doctor's to get some more medicine. When they arrive, the doctor goes to the medicine cupboard. The doctor says, "You can stop drinking the strawberry medicine. Here is the new chocolate medicine!".

Emotion judgment

Who feels happier that they are drinking chocolate medicine now? Sally? Anne? [Or do they feel the same?].

Scenario B: Party

Introduction to characters

Charlie and Michael are friends. Sometimes they like doing the same things, and sometimes they don't like doing the same things. Charlie and Michael both really love playing pass the parcel. Michael really doesn't think bouncy castles are fun, while Charlie thinks bouncy castles are only a bit of fun.

Counterfactual version

Charlie and Michael have been invited to the same party. They are both enjoying the party, and there are lots of games the children all play together. The parents are getting a bouncy castle ready. But they can't get it pumped up! The parents tell the children, "You were going to play with the bouncy castle, but we couldn't get it pumped up. So we will play pass the parcel instead!".

Temporal version

Charlie and Michael have been invited to the same party. At the party the parents say that the children will play on a bouncy castle first and then they will play pass the parcel. Their parents bring out the bouncy castle. They play on the bouncy castle for a while. But then that is over and now it is time for pass the parcel.

Emotion judgment

Who feels happier that they are playing pass the parcel now? Charlie? Michael? [Or do they feel the same?].

Scenario C: Singing

Introduction to characters

Sarah and Charlotte are friends in the same class at school. Sometimes they like doing the same things in school, but sometimes they don't like doing the same things. Sarah and Charlotte both love coloring in. But Sarah really doesn't like singing in class, while Charlotte thinks singing in class is just okay.

Counterfactual version

One day the teacher decides the class will do singing. She turns on the computer with the music. But the computer isn't working properly! The class will do coloring in instead. The teacher tells the class, "We were going to do singing but the computer isn't working, so we will do coloring in instead!".

Temporal version

The teacher is telling the class what they are going to do today. The teacher tells the class that today they will do singing first and then they will do coloring in. The class sings for a little while. Then the singing is over. And the class now does coloring in.

Emotion judgment

Who feels happier that they are coloring in now? Sarah? Charlotte? [Or do they feel the same?].

Scenario D: Games

Introduction to characters

Jonathan and Adam are friends. Sometimes Jonathan and Adam like to play with the same toys, but sometimes they don't like the same toys. Jonathan and Adam both really love playing with Lego. But Jonathan thinks Connect Four is kind of fun, while Adam really doesn't enjoy playing Connect Four.

Counterfactual version

Today Jonathan and Adam go to their friend's to play games. Their friend goes to the games box and gets the Connect Four game, but he sees that there are pieces missing! So he gets the Lego instead. Their friend brings back some Lego from the toy box and he says, "I was going to get Connect Four, but there were pieces missing so we will play Lego instead."

Temporal version

Today Jonathan and Adam go to their friend's house to play games. Their friend decides that they will play with Connect Four first for a while and then they will play with Lego. Their friend goes to the toy box and gets Connect Four. They play Connect Four for a while. Then they stop playing Connect Four and start playing with Lego.

Emotion judgment

Who feels happier that they are playing Lego now? Jonathan? Adam? [Or do they feel the same?].

Scenario E: Journey

Introduction to characters

Shaun and Isaac are brothers. Today, they are going on holiday with their family so they need to get to their airport. Shaun and Isaac both love the train. But Shaun thinks car journeys are just okay, while Isaac really doesn't like car journeys.

Counterfactual version

Today the family is going on holiday! The family can get to the airport by train or by car. The family is about to go to the airport by car. But because the traffic is so bad, the family decides to go by train instead.

Temporal version

Today the family is going on holiday! The family will first drive to the train station and then will get the train to the airport. So the family gets in the car and drives to the train station. The car journey is over, so they park at the train station and get the train for the rest of the way to the airport!

Emotion judgment

Who feels happier that they are getting the train now? Shaun? Isaac? [Or do they feel the same?].

Scenario F: Housework

Introduction to characters

Chloe and Rachel are sisters. They enjoy playing with their friends, but sometimes their mom and dad ask them to clean the house. Chloe and Rachel both love having their friends around to play. But Chloe thinks tidying up is just okay, while Rachel really doesn't like tidying up.

Counterfactual version

Today Chloe and Rachel's parents think the house is messy. They are going to give them tidying up jobs to do. But then they hear the doorbell ring. Chloe and Rachel's friends have turned up to the house to play. Their parents say, "We were going to give you tidying up to do, but since your friends have arrived you can play with them."

Temporal version

Today Chloe and Rachel's mom and dad are going to give them tidying up jobs to do. Chloe and Rachel's parents say that they need to do tidying up first and then they can play with their friends. Chloe and Rachel tidy up for a while. They are finished tidying up, so now they can play with their friends.

Emotion judgment

Who feels happier that they are playing with their friends now? Chloe? Rachel? [Or do they feel the same?].

Appendix B. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jecp.2022.105491>.

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