Making Inferences between Counterfactual and Real Worlds: Developmental evidence.

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Abstract

In two investigations we explored whether different aspects of counterfactual tasks, such as an alternative response mode, a different question type and additional clarifying wording could influence children's performance on such tasks.

Our first study manipulated the response mode by allowing children to answer a counterfactual task either by arrow or finger pointing, and the question type by using both standard tasks in which children were told a story and had to generate counterfactual alternatives to it and counterfactual-to-reality stories where children had to infer reality from a given counterfactual. The arrow manipulation proved to be fragile and did not influence children's performance on counterfactual tasks. The question type manipulation suggested an asymmetry between the real and the counterfactual world, with inferring reality from counterfactual alternatives easier than the reverse.

Our second study investigated whether children's performance on complex counterfactual trials, such as the discriminating trials used by Rafetseder, Schwitalla, and Perner (2013) could be supported by additional clarifying wording. We demonstrated that although children found complex counterfactual trials difficult at the age of 5 and 6, additional wording did significantly improve their performance. Children's counterfactual responses to this sort of task were supported through additional wording.

We argue that children do not find counterfactual tasks trivially easy. We also suggest that children's counterfactual reasoning could be influenced by multiple developments that occur throughout their childhood.

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1. ADULTS' COUNTERFACTUAL THINKING

This chapter aims to present a broad review of research regarding counterfactual thinking as a reasoning process and provides examples to illustrate this cognitive ability.

1.1. What is counterfactual thinking?

Very often, when people think back over what have occurred, they might say "if only..." or "what if?" and then they find different alternatives that might have happened instead. These alternatives are called counterfactuals. A central part to our everyday experience, and common in adult thinking, counterfactual thinking appears to be the cognitive process of representing events that might have occurred (e.g. Roese, 1994; 1999; McCloy & Byrne, 2000).

A very good example of counterfactual processing is offered to the audience in the 2008 film, The Curious case of Benjamin Button, when the character Benjamin Button is relating Daisy's car accident. Benjamin outlines a long and complicated series of events happening to two characters: Daisy and a woman shopping. These events led to Daisy's accident and Benjamin finds better alternatives to these events, so there would be no accident, and thus Daisy's leg would not be crashed.

The character Benjamin Button states counterfactually: "And ***if only*** one thing had happened differently: if that shoelace hadn't broken; or that delivery truck had moved moments earlier; or that package had been wrapped and ready, because the girl hadn't broken up with her boyfriend; or that man had set his alarm and got up five minutes earlier; or that

taxi driver hadn't stopped for a cup of coffee; or that woman had remembered her coat, and got into an earlier cab, Daisy and her friend would've crossed the street, and the taxi would've driven by." (Benjamin Button in The Curious Case of Benjamin Button – Fincher, 2008)

1.1.1. What are the factors influencing counterfactual thinking?

Counterfactual means contrary to the facts (Roese, 1997), therefore after a factual outcome occurs and is assessed, a set of alternatives of how the world might have been different is generated and considered. A counterfactual is, in fact, a conditional and therefore is formed of an antecedent and a consequent (Roese, 1994; 1999), both being mentally modified through imaginative means (Roese, 1999). For instance, "If I had not procrastinated for the last two months, I would have got my assignments done in time" involves undoing both the antecedent and the consequent. The antecedent refers to a fact, in this case procrastinating; the consequent is the outcome of the given antecedent - missing the deadline for an assignment. First, the person is undoing the antecedent, and considers a world where (s)he kept studying at a right pace and second, as a result of undoing the antecedent, the consequence becomes false (e.g. the deadline is met). When thinking counterfactually we are operating with a false antecedent, and therefore the factual outcome becomes contrary to the facts (Roese & Olson, 1995; Byrne, 2002).

Counterfactual thinking is influenced by several factors. A first factor is the controllability of the event. Counterfactual processing is more likely to be triggered by controllable events than by uncontrollable ones (Roese, 1997; Girotto, Legrenzi, & Rizzo, 1991; McCloy & Byrne, 2000). Hence, people tend to mentally undo outcomes that were controllable through their earlier actions and generate counterfactual alternatives to those events. For example, Girotto and colleagues (1991) presented participants with a story containing three uncontrollable events and one controllable event, followed by a tragic

outcome. The participants heard the story of Mr. Bianchi, who in his way home was delayed by three uncontrollable events: a lorry blocking the way, the passage of a flock of sheep, a tree trunk and also by his own controllable decision of stopping at a bar to have a drink. When arrived home, Mr. Bianchi found his wife lying on the floor after a heart attack. These events were rotated in each of the four possible positions in the scenario. Participants had to order the four events in order of their importance for a different outcome (not being late, and therefore saving the wife's life). Results have shown that both the type of event and the order that the events were presented were significant. The controllable event was cited as the most important in changing the outcome, even when presented as an effect of the previous events. Mandel & Lehman (1996) also supported the idea that controllable events are more likely to trigger counterfactual thoughts, but they argued that people cite controllable events not as a necessary cause for an outcome, but as a preventive measure that might have been taken.

A second factor is the ordinary or exceptional nature of the event, with unusual events triggering more counterfactuals than routine events (Gavanski & Wells, 1989; Roese, 1994). In a second experiment, Girroto et al. (1991) investigated whether exceptional events would trigger more counterfactual thoughts than ordinary events. They presented participants with the same delayed itinerary of Mr. Bianchi and with the same consequence (the death of Mr. Bianchi's wife), but now the controllable event (having a beer at the bar) was presented either as an ordinary or an exceptional event. This study supported, the previous findings, with participants rating the controllable factor as the most important in Mr. Bianchi's wife death. Also, the analysis revealed that choosing an unusual controllable event as the cause was more frequent than choosing the uncontrollable events when added together in a category, while a normal controllable event did not differ significantly from the number of mutations of the controllable events summed together. Results of this experiment showed, thus, that

participants tend to undo the uncontrollable event more often regardless of its exceptional or normal nature. Moreover, Gavanski & Wells (1989) found that participants in their research tended to mentally undo exceptional events only when the outcome was exceptional itself; but they undid both usual and unusual events equally when the result was expected. Roese (1997) argued that Gavanski & Wells' (1989) findings cannot be generalized to most of the counterfactual processes, as most evidence supports that counterfactuals are more likely to be triggered by an unusual than by an usual event (e.g. Kahneman & Tversky, 1982; Kahneman & Miller, 1986).

A third factor is the outcome-counterfactual closeness (Kahneman & Tversky, 1982; Roese, 1994); it has been argued that some alternatives that appear from counterfactual processing are closer to reality than others and therefore imply smaller changes (Kahneman & Miller, 1986). An example of such a close counterfactual is missing the train by only a few seconds; this might lead to "I nearly caught the train" – this type of processing involves smaller changes to reality than counterfactuals resulting from a situation where a person missed a train by an hour. Closeness of the outcome refers not only to temporal closeness (e.g. Kahneman & Miller, 1986), but also physical (e.g. being on long jump competition and missing the wining position by a few centimeters, compared to missing it by half a meter) and numerical closeness (e.g. not winning the lottery because a single number didn't match rather than more than 2 numbers) (Roese, 1997). Kahneman & Tversky (1982) illustrated in their research the comparison between a temporally close outcome and a possible alternative. Their scenario presented a Mr. C and a Mr. D travelling to different destinations from the same airport. The two men travelled from town to the airport together, but were caught in a traffic jam and both missed their flights. Mr. C was told that his flight was delayed and that he nearly caught the plane, while Mr. D was told that he missed his flight by 30 minutes. Most

participants judged that Mr. C – that almost made it to the flight would be unhappier than Mr. D. Both men were in the same situation, but Mr. C's counterfactual alternative was easier paired with the reality, than Mr. D's as he had to make up only five minutes compared to half an hour.

Also, it has been suggested that negative outcomes lead to counterfactual processing more often than positive outcomes (Roese, 1994). In a research study by Roese and Olson (1995), participants were read a story that involved two main manipulations: the controllability of the event and the valence of the outcome (positive vs. negative). Negative outcomes tend to lead to upward counterfactuals (thinking how things could have been better), while positive outcomes are usually associated with downward counterfactuals (imagining a worse alternative). In their scenarios a student, Susan, failed or passed a psychology test after a series of controllable or uncontrollable events. Results of this study have shown that participants engaged more in upward than downward counterfactuals. Upward counterfactuals were more often recorded in the controllable condition and in the negative scenarios, while downward counterfactuals were more often triggered by uncontrollable positive events. Upward counterfactuals could, therefore, serve the function of preventing future failures, and downward counterfactuals might make people feel better about their current situation.

Another factor that influences the generation of counterfactuals is the moral appropriateness of the event. An important question that was asked was: do all controllable events trigger counterfactuals in the same way? McCloy and Byrne (2000) tried to address this issue in one of their studies. The authors constructed a scenario based on Girotto et al. (1991 – described above) that was listing a series of four exceptional events for Mr. Ryan: a traffic jam (uncontrollable), stopping to pay a visit to the parents (appropriate and

controllable), stopping for a hamburger (inappropriate and controllable) and stopping to buy a newspaper (neutral and controllable). When he got home, he found his wife on the floor after she had suffered a heart attack. This study suggested that inappropriate controllable events led people to generate counterfactuals more often than other types of events, with more participants undoing the inappropriate event (stopping to have a hamburger) than the other events. This might leave open the question of whether it is the controllable vs. uncontrollable nature of the event that influences processing counterfactually or the appropriate vs. inappropriate quality of it.

In summary, people tend to generate more counterfactuals to events when those events are within people's control, extraordinary, negative, and of morally inappropriate nature. All these findings are though related to laboratory manipulations; therefore, this leads to the following question: how does spontaneous counterfactual thinking occur?

Sanna and Turley (1996) argued that previous findings do not refer to people's spontaneous counterfactual thoughts. One of their studies investigated the generation of spontaneous counterfactuals in a real life exam situation. Consistent with other research, (Roese & Olson, 1995) negative outcomes triggered counterfactuals more often than positive outcomes. Also, unexpected outcomes triggered more counterfactual processing than expected outcomes. McEleny and Byrne (2006) also showed that people spontaneously generate more counterfactuals when they experience an uncontrollable negative event, and that they consider specific events that could inhibit an unfavourable result, but there was no evidence that unexpected events lead to more counterfactual thoughts. Therefore, these studies suggest that negative outcomes lead to counterfactuals, not only in laboratory studies, but also in real life situations.

1.2. How do people undo reality?

People build their own mental representation to events that have occurred. Usually these are not unbiased, but modeled through the knowledge and unique features of each individual (Williams, Lees-Haley, & Brown, 1993). This section tries to identify what cognitive processes support the generation of counterfactuals.

Kahneman & Tversky (1982), pioneer researchers of counterfactual thinking, proposed that people are more likely to mentally reverse outcomes that arose due to atypical actions; they also demonstrated in their experiments that people are more prone to mentally alter actions than inactions and temporally close events than events that happened way before the actual outcome. Roese, Sanna, and Galinsky (2005) added to this that, counterfactual processing can be either automatic, or intentional. The intentional counterfactuals are usually constructed online, based on specific outcomes. Potentially, there are infinite counterfactual alternatives to a given outcome, but usually people build counterfactuals through the alteration of only one or two specific features, which in turn preserves the closeness between the real world and the imagined world (Roese, 1997; Roese et al., 2005).

Byrne (2002; 2005) further explained that counterfactuals depend on the number of possibilities that we can generate from a certain event. In the case of tossing a coin, we generate two possible true alternatives (tossing head or tail) that we keep in mind. Some events might have an endless range of possibilities, but because of the limitations of our working memory we operate with just a few. It has been suggested that we represent only the real event explicitly, while the alternatives are represented only implicitly (Johnson-Laird & Byrne, 2002). These mental representations of events could lead to a temporal order effect. This means that people tend to undo the last event out of a sequence of events in order to

generate counterfactual alternatives. For instance, a basketball fan will consider most the most recent game of a team when they judge their team place in the league.

The temporal order effect refers to counterfactually undoing events on the last characteristic of that event and is a result of certain working memory limitations (Byrne, 2002). It has been agreed that usually when imagining how losing a game could have gone differently, people undo the last event. Walsh and Byrne (2004) tested in 2 experiments whether the temporal order effect might be reversed if the game description is altered. Participants were presented with a fact (e.g. both players picked black cards) and a set of winning conditions (participants win if they pick different colours). The winning conditions were presented in Experiment 1 either by using the red disjunction (participants heard that they win if one of the players, but not both, picks a red card) or red conjunction description (win if the two cards picked are of different colours: one red and one black) and in Experiment 2 by using the black disjunction or black conjunction description. Interestingly, participants in the red disjunction condition exhibited a reversed temporal order effect by mutating more often the first character's pick, than the second character's pick. On the other hand participants in the black disjunction condition marginally showed a typical temporal effect, by undoing the last pick more often. Both red and black conjunction conditions revealed no temporal effect, with participants equally undoing both picks. These result suggested that the way we describe series of events influence the way we counterfactually undo those events.

Some studies on counterfactual emotions found an 'agency effect' (Byrne & McEleny, 2000; Gilovich & Medvec, 1995; Roese & Summerville, 2005). This "agency effect" means that people tend to undo more often acts of commission (actions) than omission (inaction) on the short term (Gilovich & Medvec, 1995); on the other hand, on the long term people seem to

regret more inactions than actions (Gilovich & Medvec, 1995; Feldman, Myamoto, & Loftus, 1999). Byrne & McEleny (2000) argue that the temporal effect of the "agency effect" could be explained by the way people store information about different alternatives. They suggest that actions are more readily mutable than inactions, as they are more explicitly mentally represented than inactions; actions imply a change of state, therefore people have to hold in mind more information (Kahneman & Miller, 1986): the original event, the change, and the outcome, whereas inactions imply no change. Byrne & McEleny (2000) demonstrated in 4 studies aspects of the "agency effect", and concluded that actions are more cognitively alterable than inactions on both the long and short term, when the outcome of both of them it is known and the same. On the other hand, inactions are more mutable than actions, in the long term, only when the outcome of the inaction is unknown. Therefore, it has been suggested that (1) people tend to undo actions more than inactions because they are explicitly represented, and (2) undoing a counterfactual inaction on the long term occurs only when its counterfactual consequences are unknown, and thus, possibly better than reality.

People mentally represent not only events, but also expectations and norms. Wellman & Sugarman (2006) examined how participants perceived a patient's dilemma based on their own behavioural expectations and personal norms. Participants were presented with a scenario about Sally, a pregnant woman who had a type of leukemia that worsens fast. Sally was caught between the choices of having chemotherapy which could save her life, but endanger the foetus, and not having chemotherapy. Both choices could have led to a negative outcome. Participants were then asked to choose one of the two courses of action, after which they were told what Sally chose. Results showed that more participants agreed with continuing rather than stopping the treatment. Participants that recommended stopping the treatment were more religious that those who did not, and have chosen this option because of

their personal beliefs. It was shown that when the baby or the mother died, participants that disagreed with the treatment decision Sally made considered Sally more responsible and attributed her more regret than when they agreed with the decision. These results suggested that people attribute responsibility in a counterfactual situation by filtering the situation through their own perceptions and expectations.

1.3. Counterfactual emotions

Important life events and decisions are commonly accompanied by intense emotional responses. As such, counterfactuals influence emotions (Gilovich & Medvec, 1995) and inferences such as causation and likelihood (Roese, 1997), which in turn influence global impressions of self and others (Miller, Visser, & Staub, 2001). One might feel really unhappy after experiencing an exam failure, while another person could have a totally different affective response in a similar situation; nevertheless, same emotions, at different levels of intensity, might be experienced in everyday life (Zeelenberg, van Dij, & Manstead, 1998). The next section focuses on the understanding of counterfactual emotions, especially regret.

1.3.1. Regret

Landman (1993) offered a great picture of regret, defining it as a "more or less painful judgment and state of feeling sorry for misfortunes, limitations, losses, shortcomings, transgressions or mistakes. It can be experienced in anticipation of a decision or retrospectively, after a decision" (p.4). It can be added that regret is an emotion that appears when we compare an actual outcome with a better outcome (Roese, 1997; Roese & Summerville, 2005) that might have been obtained had a different choice been made (Van Dijk & Zeelenberg, 2005). Regret is a concept mapped on the self; therefore people's regrets

are related to personal domains. Some findings showed that Americans regret most the bad decisions made in the domain of education, followed by career, romance and parenting (Roese & Summerville, 2005).

Regret has several differentiating characteristics, such as wanting to undo the event, to get a second chance, an intense feeling that one should have known better, rumination over a past mistake, desire to correct the mistakes that had been made (Zeelenberg, van Dijk, Manstead, & van der Pligt, 1998). Thus, regret develops from an erroneous decision making process (Roese & Summerville, 2005).

The situations that may lead to regret are often complex, and many factors should be taken into consideration when assessing what might have lead to regret. For instance, a between participants experiment was trying to establish some of the characteristics of a regrettable situation (Boninger, Gleicher, Strathman, 1994). Participants were asked to imagine themselves as being a young Olympic athlete who before a competition had the misfortune of spraining their ankle. The athlete had to choose between two painkillers: a well-known one that was effective in reducing pain but had performance-impairing effects, and a new painkiller that allegedly was more effective but whose side effects were unknown. As it is, the athlete decided for the established drug, but taking it affected their race and the athlete finished on the fourth position. After the race the athlete found out more about the new drug. Participants in the no outcome change condition find out that the new drug would have brought the same performance impairment as the well-known drug, while participants in the outcome change condition found out that the new drug wouldn't have been associated with same side effects. Participants were asked either to imagine the athlete thinking about a future race that would happen in two weeks time (focus on future) or to imagine the athlete thinking about the lost race (focus on present). As expected, participants in the outcome change

condition reported greater feelings of regret than participants in the unchanged outcome condition. Thinking about the future instead of ruminating about the past decreased the experience of regret and self-blame. This experiment suggested that people feel more regret in action than inaction scenarios, but this could be decreased if they chose to focus on future events, instead of ruminating about the past ones.

"The agency effect" (Byrne & McEleny, 2000) was found to be a characteristic of regret (see section 1.2.). First, Kahneman & Tversky (1982) found that action regret is more common that inaction regret. They created a scenario presenting two men: Mr. Paul and Mr. George, who both had stock in two companies. Mr. Paul considered changing his stock to a different company, but he decided not to – his inaction makes him lose $1200. Mr. George changed his stock from a company to another, and he found out he would have been more fortunate (by $1200) if he hadn't leave the previous company. Even though both men lost the same sum, 92% of the participants considered that Mr. George will regret his action, whereas only 8% said that Mr. Paul will regret his inaction. This study revealed that actions are more regretted than inactions.

Feldman et al. (1999) investigated the effect of action/inaction on regret. Over 600 students were asked to recall a regret they had because of something they failed to do, because of something they did, or they could just recall a regret of their choice. Action regret was not found to be more intense than inaction regret; moreover, in the free choice condition, more inaction regrets were recalled by the participants. To add to this, participants of a survey (Gilovich & Medvec, 1995) that were asked "When you look back on your experiences in life and think of those things that you regret, what would you say you regret more, those things that you did but wish you hadn't, or those things that you didn't do but wish you had?" (p. 383) recalled more inaction regrets than action regrets. Davidson & Feeney (2008) added to

the action/inaction regret evidence, by suggesting that people in their 40s and 60s regret failing to act at an early point in their lives – this long term inaction regrets were mostly general regrets (these regrets could not be placed in a specific time frame), while their recent regrets are more specific and refer more to actions than inactions. These three studies supported the idea that that people regret more, on the long term, their inactions than their actions.

Other factors, such as the certainty of counterfactual outcomes seem to influence people's experience of regret. In one experiment (Van Dijk & Zeelenberg, 2005), participants played a game that could have ended with winning different prizes; but participants always won a little ball. After participants made their choice, they either found out what the prize would have been had they made a different choice, or they found out all the other prizes, without specifically knowing what they lost. All the alternative prizes were more valuable that the won prize. Participants reported greater levels of regret when they knew what they missed, than when they were uncertain about their loss. This suggests that uncertainty about a counterfactual outcome might play a role in reducing feelings of regret.

Another factor influencing how much regret we experience is attribution of responsibility (Roese & Olson, 1995; Markman & Tetlock, 2000; Zeelenberg, van Dijk, & Manstead, 1998). Zeelenberg et al. (1998) investigated whether regret is influenced by feeling responsible for an obtained outcome. Participants heard a story about two students that were either reassigned to different study groups than their initial ones, or they chose to change their initial study groups with a new one. The story also included a student that did not change his study group. All three students ended up in the same group. After a while, these students found out that one of the groups was much better, while the other one was much worse than their current group. Participants attributed greater levels of regret in the condition where one

of the students chose to move to a worse group than he was reassigned to that group. Thus, the more responsible one of the characters was judged to be, the more regret is attributed to that character. Counterfactual denial of responsibility (Markman & Tetlock, 2000) might then reduce feelings of regret.

Taken together, the evidence presented suggests that regret is a subjective judgment or state of feeling sorry for one's misfortunes that is triggered on the short term by counterfactually considering acts of commission (Boninger et al., 1994; Kahneman & Tverksy, 1982), and on the long term by acts of omission (Gilovich & Medvec, 1995), by attributed responsibility (Roese & Olson, 1995), and that is decreased by uncertain counterfactual outcomes (van Dijk & Zeelenberg, 2005). The next section will try to distinguish between different counterfactual emotions.

1.3.2. Other counterfactual emotions

There are other counterfactual emotions such as relief, disappointment, envy, blame, guilt or shame, but due to space limitations we cannot discuss them in detail. We will briefly mention relief, envy and disappointment.

Relief is an emotion that develops from a downward counterfactual, by comparing an actual outcome with a worse possibility. Usually, relief is the result of comparing a previous negative state with a current positive state, or of avoiding a possible negative state (Sweeny & Vohs, 2012). Sweeny & Vohs (2012) argue that avoiding a negative state and completing a negative task trigger qualitatively different feelings of relief. Their study suggested that avoiding an imminent negative state is associated with downward counterfactual thoughts and feelings of social isolation, whereas completing a negative task is associated with upward counterfactual comparisons. In a further study, Sweeny & Vohs (2012) showed that relief predicted feelings of social isolation; moreover, counterfactual thinking significantly

mediated the relationship between these variables. Relief is worth studying given its social consequences.

Another counterfactual emotion then we might experience, especially as a consequence of upward comparisons is envy. Envy usually arises after comparing oneself with somebody else that had better achievements and involves either a painful desire of achieving the same superiority as another person or a strong wish that the other person would lack their superior qualities. Despite its negative valence, envy may, at times, act as an enforcement by motivating the person who experiences it to try for better (van de Ven, Zeelenberg, & Pieters, 2009).

Disappointment is similar to regret and arises from comparing a given outcome to a better outcome that might have been obtained if the same choice had been made. Disappointment has been differentiated from regret on a few characteristics. This emotion involves feeling powerless, avoiding and trying to get away from the unpleasant situation, and a tendency and desire to do nothing - which could lead to learned helplessness (Zeelenberg, van Dijk, Manstead, & van der Pligt, 1998).

1.4. What are the neurobiological systems involved in CF?

In recent years, the neurological basis of counterfactuals was investigated. It is widely accepted that the prefrontal cortex it is crucial in executive control of behaviour. Ursu & Carter (2005) showed in two fMRI (functional Magnetic Resonance Imaging) experiments that the lateral side of the orbitofrontal cortex was activated during the trials that signaled possible penalties, while the medial and dorsal areas of the prefrontal cortex appeared to be activated during the expectation phase of reward trials. An increased activity in the ventro-medial foci occurred during reward trials compared to neutral or penalty trials. These results

suggested that the orbitofrontal cortex is implicated in the counterfactual weighting of different possible alternative outcomes, and the lateral areas of the prefrontal cortex hold representations of emotions resulted from a negative outcome, while the medial and ventral areas have a role in representing the affective impact of positive outcomes.

To add to this picture, Van Hoek, Ma, Ampe, Baetens, Vandekerckhove, & van Overwalle (2013) investigated through an fMRI scanning whether counterfactual thinking activates a specific part of the brain. Participants randomly received 20 past trials (imagining a past event), 20 future (imagine a positive future event), and 20 counterfactual trials (imagine a better outcome), after which they had to rate the vividness of each imagined event (i.e. they rated whether they imagined little, few, many and a great many details). This study revealed that (1) all types of trials activated the hippocampus, parietal and temporal lobe – which are representing the memory network, but also the right prefrontal cortex – which is associated with executive control, and (2) counterfactual thinking led to greater activation in the frontal cortex, in the bilateral inferior parietal, right temporal pole, left middle temporal gyrus and left cerebellum than past and future trials. These results suggested that all types of trials shared a common neurological ground; their association with memory network areas suggests that people might construct mental representations about past, future, and counterfactual alternatives based on memory. Also, the posterior medial frontal cortex and the prefrontal cortex, activated during counterfactual reasoning, are also associated with causal reasoning, conflict detention, and adaptive control. Counterfactual thinking is a form of causal reasoning that requires simultaneously considering two contradictory events, mentally undoing a past event, and also predicting how the counterfactual outcome will look like. Hence, all these mental processes require solving the conflict between real and counterfactual events, and require executive control.

Another important development made in the literature, was to determine what brain areas are involved in counterfactual emotions. Camille and colleagues (2004) presented healthy participants and patients who sustained an injury of the orbitofrontal cortex with two gambling choices that were associated with either reward or loss. As expected, all participants experienced more pleasant emotions when they were rewarded than when a negative outcome occurred. Participants without an injury experienced both disappointment and regret (as subjectively rated by participants, and also measured as skin conductance response), but the patients with orbitofrontal cortex lesions did not experience regret which highlights the role of orbitofrontal cortex in experiencing regret. The affective states of participants with sustained lesions did not depend on the outcome of the unchosen gamble; also, they did not learn to avoid the gamble most likely to be associated with loss; therefore they did not develop behavioural strategies from experiencing regret.

Another development in the field happened by testing whether observing and understanding regret in others activates the same areas as the direct experience of regret. Canessa, Motterlini, Di Dio, Perani, Scifo, and colleagues (2009) conducted an fMRI study assessing the 4 conditions of a classic gamble: I play, other plays, I follow, and other follows; this gamble resulted in real win or losses. The "other" conditions involved a computer playing and participants just observing the game. Participants were told that the other person's gamble will result in gains or losses for them. After the gambles, participants could assess the result of their own or other's choices. The fMRI scanning revealed activity in the ventromedial prefrontal cortex, left amygdala, and in the hippocampus, and also in the hippocampal gyrus, postcentral gyrus and thalamus for both types of regret (I versus other). Thus, this suggests that understanding regret in others is supported by the activation of same cerebral areas as the direct experience of regret.

1.5. What are the functions of counterfactual thinking?

"Without considering alternatives to reality, we must accept the past as having been inevitable and must believe that the future will be no different from the past. The generation of counterfactuals gives us the flexibility in thinking about possible futures and prepares us better for those futures" (Johnson & Sherman, 1990, p. 150).

Considering the information from previous sections, it is to be expected that we question what the purposes and functions of counterfactual thinking are. It was suggested that upward counterfactual thinking plays a function in preparing individuals for the future, whereas downward counterfactual thinking plays a role in improving negative states that followed a given outcome (Roese, 1994; Markman, Gavanski, Sherman, & McMullen, 1993).

1.5.1. Upward counterfactuals

Upward counterfactuals result from comparing the real outcome with a better counterfactual alternative; this comparison might worsen the valence of the real outcome and lead to negative affect (Markman et al., 1993). Nevertheless, experiencing upward counterfactuals might facilitate future success through imagining paths to better counterfactual alternatives that could be transposed into future actions (Markman et al., 1993).

In one of the first experiments investigating the function of counterfactuals, Markman and colleagues (1993) used a computer simulated blackjack game condition; participants' game resulted in monetary wins or losses. The game was manipulated so that all participants ended up with $5. Participants were assigned either to a win (starting with no money and winning $5), neutral (starting with $5 and keeping them), or lose (starting with $20 and losing $15) condition. Moreover, participants were split into repeat and no-repeat, so that participants in the repeat conditions were told that they will be playing 4 blackjack games,

while participants in the no-repeat condition played just one game. The results showed that participants generated more upward counterfactuals after a negatively valenced outcome, and in the repeat conditions; also participants in these two conditions reported less satisfaction than participants in the neutral, win, and no-repeat conditions. Markman and colleagues argued that upward counterfactuals were more common during the repeat condition than the no-repeat one, as participants wanted to improve future results by preparing and assessing how the outcome might have turned better.

Roese (1994) added to Markman et al.'s (1993) findings, by providing direct evidence for the preparative function of the upward counterfactuals. In three experiments, Roese (1994) demonstrated effects of direction and structure of counterfactuals on mood and preparedness. Participants had to describe a past negative event (study 1), failure on a recent exam (study 2), or to solve two computer administrated anagrams in a given time. All three studies found that upward counterfactuals are associated with negative affect. Study 2 suggested that generating upward counterfactuals increased participants' reported intentions of engaging in actions that would facilitate future success. Study 3 revealed more direct evidence supporting the preparatory function of upward counterfactuals. Participants that after solving the first anagram set engaged in upward counterfactual thinking improved their performance on the second set considerably more than participants that engaged in downward counterfactuals. Taken together, these studies revealed that upward counterfactuals are associated with negative affective states and that they serve a preparative function in acquiring future success.

To provide further support, Morris & Moore (2000) investigated how counterfactual thinking applies to the real world. In study 1 the authors investigated archival reports filled by experienced pilots after dangerous incidents and tried to identify counterfactual statements and any statements regarding future plans; in the second study college students operating a

flight simulator were asked to describe any aviation incidents that occurred during the flight and to think how they could improve their future performance. In both experiments, counterfactuals were triggered by negative events. Self-focused upward counterfactuals were more often reported than downward or other-focused counterfactuals. Also, self-upward counterfactuals were associated with plans for future improvements. Overall, Morris & Moore's (2000) findings support the view that upward counterfactual comparisons, centered on own actions rather than other's actions, facilitate the formulation of plans and have a learning function.

Moreover, Epstude and Roese (2008) argued that counterfactuals influence people's future performance either through supporting behavioural intentions, or through activating specific mindsets and motivation. In support to this claim, Smallman and Roese (2009) demonstrated in three studies that counterfactuals are linked to behaviour regulation by facilitating the response times for behavioural intentions.

It has also been suggested that focusing on the future might influence the affective response to counterfactual thinking (Boninger et al., 1994). For example, individuals might feel less negative counterfactual emotions if they will consider future implications of their actions instead of ruminating about past events. Counterfactual processing might prove beneficial in helping individuals to plan for the future (Boninger, et al., 1994; Roese, 1994), and in preventing the same negative situation from occurring in the future (Byrne, 2002).

In conclusion, upward counterfactual thoughts appear as a result to negative events and outcomes and were demonstrated to increase preparedness for future similar situations (Roese, 1994; Mooris & Moore, 2000), especially when that event is likely to occur again (Markman et al., 1993).

1.5.2. Downward counterfactuals

Downward counterfactuals are the result of comparing reality with a worse alternative; oftentimes they start with "at least..." (e.g. if I had taken my umbrella last week, [...I wouldn't have gotten wet and...] I wouldn't have gotten this bad cold. But *at least* I didn't get pneumonia). This type of counterfactual serves to reduce negative feelings that follow a bad outcome, or to increase positive affect that follows a positive outcome; however, they do not prepare the individual for future events (Markman et al., 1993). In their computer simulated blackjack game, Markman et al. (1993) found that downward counterfactuals are associated with positive outcomes and with non-repeated games. The authors argued that given the fact participants played a single blackjack session, engaging in downward counterfactuals generation acted as a defensive mechanism, as people try to find the positive side of the given outcome (at least I have $5) and comfort themselves.

Roese's (1994) findings also supported the idea that downward counterfactuals are associated with positive affective states. Moreover, study 2 provided direct evidence that engaging in downward counterfactuals after obtaining an unsatisfactory exam grade resulted in mood improvement.

There is evidence suggesting that both upward and downward counterfactual thoughts are serving a similar function. Kray, George, Liljenquist, Galinsky, Tetlock, & Roese (2010) showed that counterfactually considering unusual pivotal moments enhanced people's tendency of attributing meaning and of considering the beneficial impact of that moment. This study suggested that counterfactuals are not just an instrument for rumination over past moments, but they might be a great tool in creating meaning, which in turn might help answering fundamental questions such as "why are we here" and "what is the meaning of our existence".

1.6. Brief conclusion

This chapter indicated that people often think how the past might have been different by mentally undoing aspects of past events (e.g. Roese, 1997; Kahneman & Tversky, 1982; Girotto et al., 1991; Byrne, 2005). Engaging in counterfactuals often leads to a wide array of emotions, such as regret, relief, guilt, disappointment. Oftentimes, counterfactuals are associated with negative affective states (Medvec et al., 1995); nevertheless, they might serve a behaviour regulating function and might lead to improvements in future performances (Smallman & Roese, 2009; Roese, 1994). It is, thus, important to understand how this reasoning process develops. The next chapter seeks to review the developmental trajectory of counterfactual thinking.

2. CHILDREN'S COUNTERFACTUAL THINKING

The previous chapter presented evidence that counterfactual thinking is a common form of reasoning in adults. The purpose of this chapter is to focus on counterfactual research conducted with children. Recently, researchers have debated the age children start engaging in counterfactuals (e.g. Harris, German, & Mills, 1996; Harris, 1997; Riggs, Peterson, Robinson, & Mitchell, 1998; Beck, Robinson, Carroll, & Apperly, 2006; Rafetseder & Perner, 2014). This review aims to determine the age around which children acquire adult-like counterfactuals and the cognitive processes that underpin it.

2.1. Evidence of early counterfactual thinking

Young children find counterfactual tasks difficult (Riggs et al., 1998; Robinson & Beck, 2000; Guajardo & Turley-Ames, 2001). They tend to commit reality errors when answering counterfactual tasks (such as "what if Joey hadn't forgotten his umbrella, would his clothes be wet or dry?") and answer with what actually had happened instead of what could have happened (Rafetseder, Cristi-Vargas, & Perner, 2010). With age, counterfactual reasoning improves in typically developed children, but it is impaired in the autistic spectrum (Leevers & Harris, 2000; Grant, Riggs, & Boucher, 2004; Scott, Baron-Cohen, & Leslie, 1999).

Many researchers sought to investigate the age at which children can engage in counterfactual thinking. Harris, German and Mills (1996), Harris (1997), and German and Nichols (2003) claimed that children's first counterfactual thinking occurs by the age of 3.

However, Riggs et al. (1998) and Guajardo and Turley-Ames (2004) did not find any evidence of counterfactual thinking before the age of 4. Some researchers have suggested that children engage in adult-like counterfactuals after the age of 5 (Beck, Robinson, Carroll, & Apperly, 2006; Rafetseder, et al., 2010; Ferrell, Guttentag, & Gredlein, 2009). We will try to review these studies, in an attempt to organize our knowledge regarding children's counterfactuals.

One of the first signs of counterfactuality in children can be considered pretend play, which emerges between 18 and 24 months (Leslie, 1987). Amsel and Smalley (2000) describe an example of pretend play where a child plays with a banana and uses the fruit as a telephone. The assumption that was made is that children engaged in pretend play have the capacity to deny current states of affairs and generate a different world to that current state (e.g. deny that banana is a fruit and consider an alternative where banana is a yellow telephone).

Harris (1997) further suggested that children younger than 3 could understand the counterfactual "almost". This almost refers to unrealized outcomes; for instance, a horse gallops toward the end of a table and almost falls which means that the horse did not fall, but could have fallen if it had galloped any further. In Harris' (1997) study, two- and three-year-olds watched two horse toys galloping on a table. One of the horses stopped well before the edge, while the second horse stopped right before the edge, being in the verge of falling. When asked which horse almost fell, even two-year olds were able to indicate the right horse. This outcome supported an early emergence of basic counterfactual reasoning, with children under three years of age correctly referring to unrealized outcomes with terms such as nearly and almost.

Beck and Guthrie (2011) investigated whether 2- and 3-year-olds understand counterfactually the word 'almost. They ran a similar study to Harris (1997) with 3- to 4-year-olds watching the same sequence of two horses galloping on a table; they obtained same results as Harris. In a second study, children between 3 and 4 years of age saw a horse that stopped just before falling, and one that actually fell. This second study revealed that children pointed at the horse that actually fell as often as at the horse that almost fell. There was no difference between the children's performance in this new condition and performance predicted by chance. These results suggest that children might not use "almost" counterfactually, but they might in fact see "almost" as an indicator of the imminence of a certain outcome. In a third experiment Beck and Guthrie (2011), demonstrated that 5- to 6-year-olds can differentiate between the horse that almost fell and the one that actually fell. Harris's (1997) claim that children, as young as 2, can make a counterfactual interpretation of a close event does not seem to be supported.

One of the first developmental investigations of counterfactuals was run by Harris, German and Mills (1996) who enacted four standard counterfactual stories for three-and-a-half-year-olds and four-and-a-half-year-olds. All of the stories consisted of a causal chain of events (the antecedent) followed by an outcome (the consequence). Children had to judge how the world would be if the event had not happened. For instance, one scenario describes a character, Carol, stepping with her dirty shoes on a clean floor. Children saw the clean floor, the process of getting the floor dirty (they watch a doll walking in with her dirty shoes) and the result (the dirty floor). Children had then to answer the question: "What if Carol had taken her shoes off - would the floor be dirty?"(p.238). The authors found that the 4-year-olds gave the correct answer in most of the cases (86.5%) and so did the 3-year-old children (75%). Another two experiments conducted by these authors suggested that children, as young as 3,

are demonstrating counterfactual reasoning when responding to questions such as "what if this event had not happened, how would the world be?"

Despite Harris and his colleagues' (1996) claims, there is evidence indicating that children cannot engage on counterfactual thinking by the age of 3. Riggs and colleagues (1998) examined the relationship there is between performance on false belief tasks and counterfactual tasks. Both of these tasks required the child to deny their own way of seeing reality; the counterfactual task asked children to imagine how the world would had been had the antecedent had not happened. In one of their experiments, Riggs et al. (1998) enacted two stories: a Post Office Story and a Chocolate story. The Post Office story described Peter as being ill and resting in bed; while he was in bed, his partner Sally went to the store. In the meantime, Peter received a phone call about a fire that started at the Post Office. Peter went to the Post Office and helped to put out the fire. Children were asked the counterfactual question: "Where would Peter be, if there had been no fire?" and the false belief question: "Where does Sally think Peter is?" (Riggs et al., 1998, p. 76). Children made realist errors in both types of tasks; also the performance on the two tasks was significantly correlated. The authors suggested that the similarity shared by the two types of tasks could be a result of a similar level in verbal capacity. Further studies revealed that counterfactual reasoning accounted for performance on false belief tasks. Understanding counterfactual states is not sufficient for acknowledging false beliefs, but it seems to be necessary. Despite the findings made by Harris et al. (1996), this study suggests that counterfactuals still prove difficult at the age of 4.

Thus, there are two conflicting views on whether 3-year-olds can reason counterfactually. While Harris et al. (1996) argue that 3-to 4-year-olds have a good performance on standard counterfactual tasks, Riggs et al. (1998) found that children in this

age group have a poor performance on standard counterfactual tasks. This different result could be due to differences in the used tasks. Harris and colleagues used simple sequences of events that resulted in a negative outcome; on the other hand Riggs et al. stories used a more complex sequence of events that usually resulted in changes that were more abstract (e.g. location changes). However, Robinson and Beck (2000) argued that children in Harris et al.'s study were not required to use counterfactual thinking to solve those counterfactual tasks, as they were only required to consider whether the given outcome could have been avoided.

German and Nichols (2003) proposed a different explanation for the conflicting results of Riggs et al. (1998) and Harris et al. (1996). They argued that Harris and colleagues presented a simple scenario where a single mishap happened, but in Riggs et al. the scenario was much more complex and children had to build a longer inference chain to get to the right answer. They suggested that going back in time to a point when more than a few possibilities are available to happen might pose difficulties for children. German and Nichols considered that the length of the inference could influence children's solving of causal counterfactual chains. A group of 3- and one of 4-year-olds were presented with 2 stories encompassing a sequence of 3 events. For instance, one of the stories depicted Mrs. Rosy being happy as she finished planting some flowers, in her garden. She called out her husband (event 1) who came out the door and clumsily let the dog escaping (event 2); the dog ran into the garden and squashed Mrs. Rosy's flowers (event 3). As a consequence, Mrs. Rosy was sad. Children were asked either a long question ("what if Mrs. Rosy hadn't called her husband, would Mrs. Rosy be happy or sad?"), a medium question ("What if the dog hadn't escaped from the house, would Mrs. Rosy be happy or sad?") or a short question ("What if the dog hadn't squashed the flower, would Mrs. Rosy be happy or sad?") (p. 517).

Results of German and Nichols' (2003) study showed that children in the short inference condition outperformed both children in the medium and long inference conditions. In the medium and long chain conditions, only the older groups performed above chance. These results support the idea that children in Harris et al.'s (1996) study can infer counterfactual conclusions based on a short simple causal chain. This study suggested that while 3-year-olds can handle short causal chains, only from the age of 4 onwards children are able to solve longer counterfactuals, once they can process complex information.

There is some evidence suggesting that 3-year-olds' performance on short causal chains is the result of false positives. Beck, Riggs, and Gorniak (2010) responded to German & Nichols's (2003) study, but failed to replicate their findings. Beck and colleagues argued that short causal chains might have been answered so easily by such young children because they used general knowledge, but not necessarily because counterfactual thinking emerges at such a young age (see also Rafetseder & Perner, 2010; Rafetseder, Schwitalla, & Perner, 2013). Children might have given the right answer to the question "What if the dog hadn't squashed the flower, would Mrs. Rosy be happy or sad?" by using their general knowledge that seeing squashed flowers makes people sad.

In order to test both possible explanations: precocious counterfactual reasoning and use of general knowledge, Beck et al. (2010) created 4 conditions: a short, and a long emotion condition, and a short and a long location change condition. Children between 3 and 4 years of age heard stories similar to those used by German and Nichols (2003) and were asked one short emotion question (What if event 1 had not happened?), one long emotion question (What if event 3 had not happened?), one short location question (regarding event 1), and one long location question (regarding event 3). Beck et al. proposed that both short emotion and

location change trials should be easier for 3- to 4-year-olds than long emotion and location change trials, so that German and Nichols' results were supported.

Beck et al. (2010) did not support German and Nichols' (2003) claim. Two of the four experiments conducted reported children performing equally well in all conditions; therefore there were no significant differences between conditions. The other two studies found no difference in difficulty between the long emotion and the long location change chains, but the short location chains were found more difficult than short emotion chains, but also more difficult than the long questions. Surprisingly, it was found that children answered better in the long conditions than in the short conditions. This later finding did not provide support for either of the two possible explanations: precocious counterfactuality or the use of general knowledge.

A fifth experiment by Beck et al. (2010) investigated children's linguistic ability and its relation with long and short causal chains. The results showed that children with poorer performance on the linguistic ability scale (British Picture Vocabulary Scale), performed worse in the short causal chain condition than on the long causal chains. No differences were recorded between the high scorers on the British Picture Vocabulary across different conditions. Also, children with high scores on the language measure outperformed those with low scores, on the short causal chains. Beck et al. concluded that once children reach a certain level of linguistic maturity and mastery of specific grammatical structures, the length of the causal chains does not matter anymore in counterfactual solving (also see Beck et al., 2009).

Other types of counterfactual tasks, syllogisms – that require children to work with illogical information – was investigated by Richards and Sanderson (1999); they checked whether imaginative cues might improve deductive reasoning ability on syllogisms containing contrary-to fact assertions in 2-, 3, and 4-year-olds. Children were assigned to 4 conditions.

One condition was represented by the controls which received the syllogisms without receiving any other cues; the second group received the low imagination cues; and the third and fourth groups received highly imaginative cues that for one group meant visual imagery, and for the other pretending to be on a fantasy planet. All participants were given instructions in line with the group they were part of. Children heard a story that "might sound a bit funny" followed by two alternative answers one of which was empirically correct, whereas the other was logically correct. For instance, one of the syllogisms was stating: "All sheep ride bicycles. Bill is a sheep. Does Bill ride a bicycle?" Children had to justify their answers. Results have shown that participants in the high imagery conditions (fantasy world and visual imagery) outperformed participants in the no cue and low imagery condition. Moreover, it was observed that children in high imagery conditions gave more theoretical justifications than children in no cue and word cue conditions. These findings suggest that when prompted, children might demonstrate logical counterfactual thinking and might inhibit reality-related responses. This study does not offer an answer regarding the three different age groups, as all ages were analysed together, but regardless of their age children in the high imaginative conditions outperformed children in the low imaginative conditions.

2.2. Further developments in counterfactual thinking

2.2.1. Executive functions.

Some theories tried to explain the deficit that seems to accompany the performance of young preschoolers on counterfactual tasks. One of the possible explanations is a deficit in executive functioning. This perspective sees poor performance not as a conceptual limitation, but as the incapacity of transposing knowledge into action.

Executive functions are an interdependent set of abilities that are thought to underpin many cognitive processes (such as theory of mind e.g. Riggs et al., 1988; or counterfactual reasoning e.g. Beck et al., 2009) and to direct intentional behaviour. Inhibitory skills seem to play a substantial role in performing false belief and counterfactual tasks. Robinson and Beck (2000) suggested that immature inhibitory control places extra demands on children's counterfactual thinking. Children very often make realist errors in counterfactual tasks, answering with how the world is instead of how it could have been. Another executive function that might explain children's difficulties in giving the correct counterfactual is shifting between mental sets. Also, working memory might play a crucial role in holding in mind both the real world and the counterfactual world. Inhibitory control might prove crucial considering that most executive functions involve certain types of inhibitory control: working memory may require ignoring the old set of irrelevant information, shifting may require inhibiting the use of an old set of currently incorrect rules (Miyake, Friedman, Emmerson, et al. 2000).

Beck, Riggs, and Gorniak (2009) analysed the performance of 3- and 4-year-olds on a battery of counterfactual tasks encompassing short causal chains (see German & Nichols., 2003), long causal chains (see German & Nichols, 2003), location change counterfactuals (see Beck et al., 2010) and false syllogisms (see Richards & Sanderson, 1999). The present study compared children's performance on a battery of counterfactual thinking tasks with performance on inhibitory control and working memory tasks; the main goal was to find out if the same construct could account for different counterfactual measures. The authors used an array of measures in order to tap all the important concepts involved in this research and also a verbal ability test. Results revealed that language and inhibitory control, but not working memory, were significant predictors for counterfactual tasks. These results support the idea

that children of young age have difficulties in inhibiting a current state of affairs and creating a parallel, alternative world. The results also suggested that language could be a prerequisite for general cognitive development, or a tool necessary to create new complex worlds, such as the counterfactual one. Also, Beck et al. (2009) failed to replicate German and Nichols' findings as children's answer to sort and long causal chains did not differ.

Perner, Sprung, & Steinkogler (2004) investigated the factors that could contribute in making counterfactual tasks difficult in 3-to 5-year-olds. They used a task which consisted of a simple transport scenario (Fig. 1) and of a complex transport scenario (Fig. 2). Children heard a story about Sue and Peter being at home. This story was followed by two types of questions for each scenario. The hypothetical questions for the simple and complex scenarios took the form: If Sue goes to the boat house and takes the boat where will she end up? The second type of questions consisted of the counterfactual questions (e.g.: If Sue had gone to the blue station and had taken the bus, where would she have ended up?). There was clear evidence that children found hypothetical questions less difficult than they found the counterfactual questions. Also, children gave more correct answers in the simple scenario, than they did in the complex scenario. This difference between simple and complex scenarios could be the result of overloading the working memory.

Figure 1. Simple travel scenario adapted from Perner et al. (2004)

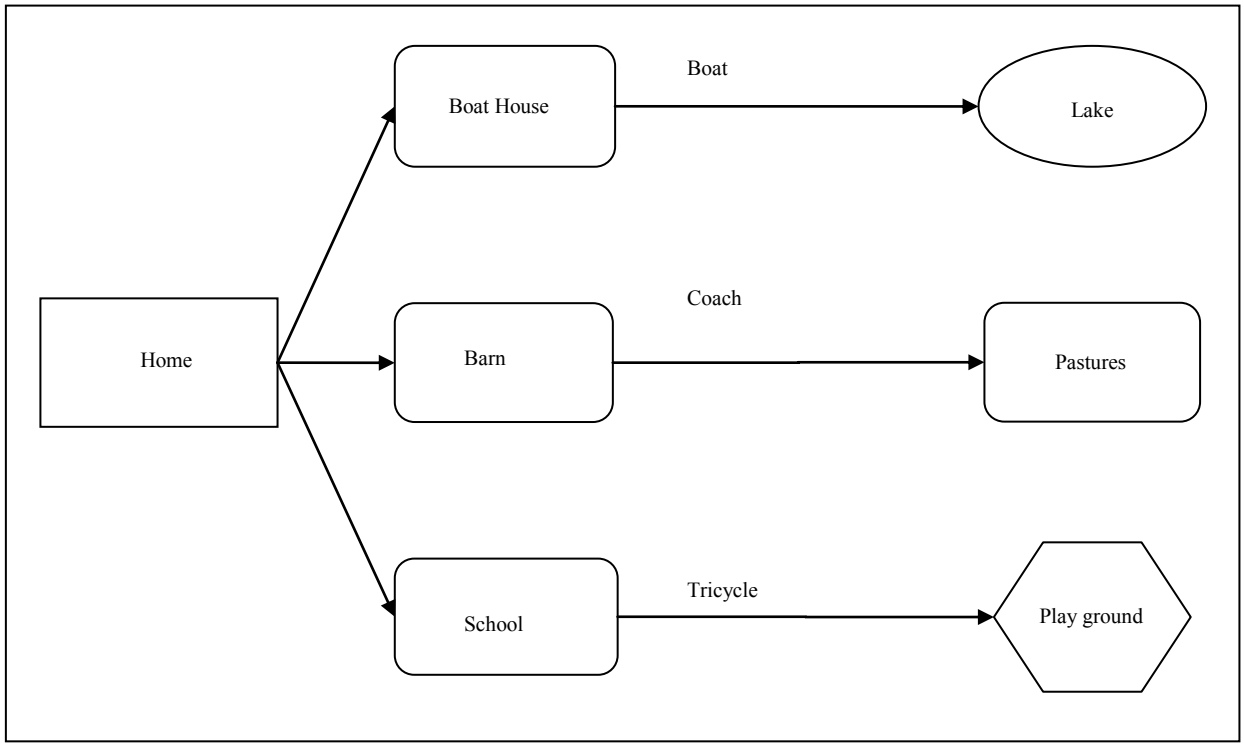
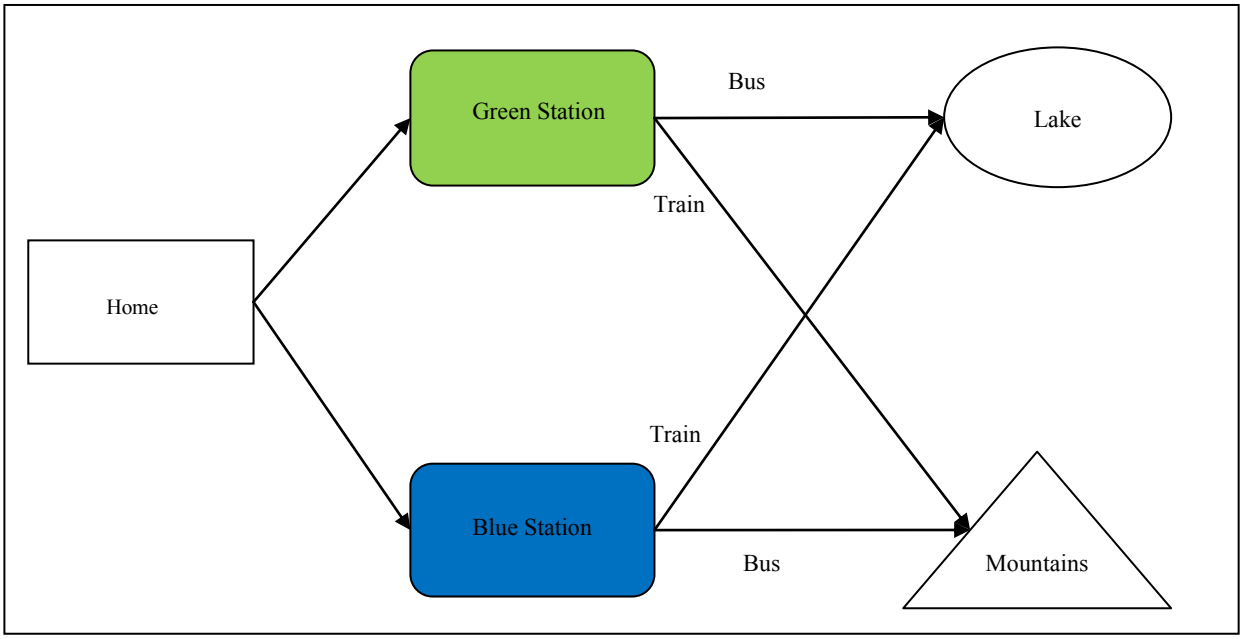


Figure 2. Complex travel scenario adapted from Perner et al. (2004)



2.2.2. The development of multiple possibilities: a possible role for working memory

Guajardo and Turley-Ames (2004) investigated the way 3-, 4-, and 5-year-olds generate different types of counterfactuals. The counterfactual task used in this study included four scenarios: children had to imagine a series of events (e.g. play in the muddy garden, run inside, and keep muddy shoes on), followed by a mishap (e.g. dirty floor). Children were then asked: "What could you have done so that the kitchen floor would not have gotten dirty?" They were encouraged to give as many answers as possible. This sort of task differs from the ones described so far in the way that children were encouraged to generate multiple possibilities themselves. Two of the scenarios were designed for downward counterfactuals (e.g.: What could you have done so your clothes would have gotten dirty?) and two scenarios for upward counterfactuals (e.g.: What could you have done so that the kitchen floor would not have gotten dirty?). Adding antecedents to reality was coded as "additive", while subtracting antecedents was coded as "subtractive". Consistent with findings from adult counterfactual literature (Thompson & Byrne, 2002), children generated more additive counterfactuals than subtractive ones, the later ones being very uncommon. Children's performance improved with age, which suggests that children gradually improve their ability to generate alternatives antecedents. Introducing counterfactuals in different forms was an extension brought to previous literature. Additive counterfactuals might tap developments such as understanding of different possibilities.

Children's ability to consider multiple alternatives, and to manage to inhibit describing the world as it is, supports counterfactual and hypothetical thinking in children. Beck, Robinson, Carroll, and Apperly (2006) researched both types of thinking in two of their studies. Hypothetical thinking is usually expressed through the question: What if X happens, how will the world be? Therefore, a future hypothetical question refers to an uncertain future

event. Beck et al. (2006) predicted that understanding future hypothetical and counterfactual scenarios is underpinned by the ability to acknowledge that multiple possibilities may occur in time. Thus, at a certain point in time more than one outcome could occur, but only one alternative will emerge into a real outcome (Byrne, 2002; 2005).

Beck et al. (2006) investigated children's ability to understand different possibilities by asking them open questions about how things could have occurred. Children aged 3-to 4, and 5-to 6-years-old were part of a game. The materials used were 1 blue vertical slide that had only one exit and one red slide that had 2 exits. The tube that the red slide was made of had a gate and then bifurcated in a stripy and, respectively, a spotty slide. A toy mouse was released on these slides, and in order to ensure a safe landing for the mouse, a cotton wool mat was placed by the child at the base of the relevant exit(s). The design encompassed future hypothetical trials and undetermined trials. In the hypothetical trial two face-down red cards were placed in front of the child (without the child knowing so), the mouse was placed on the red slide and once it reached the gate, the child could choose from a face-down stripy and spotty set of cards, so one of the exits was determined. A cotton wool was placed so the mouse could land safely. The same happened in the undetermined trial, but the child had to place the mat where the mouse could land before picking a card. Children were encouraged to think of all the possible exits. Results showed that almost all children gave the correct answers for the future hypothetical trials. Nevertheless, only 21% of the younger children and 37% of the older ones placed one matt for each exit of the red slide in the undetermined trials. These results suggested that understanding future hypotheticals was not underpinned by understanding multiple possibilities.

Beck et al. (2006) ran a second experiment. The age group slightly changed, as the older group now was formed of 5- to 6-year-olds; the younger group's age range did not

change. Children played the same game for the undetermined trials, but new counterfactual trials were added. In the counterfactual trials, children saw a cotton ball landing freely on any of the two exits and answered either to: "What if it had gone the other way, where would it be?" (standard counterfactual) or to: "Could it have gone anywhere else?" (open counterfactual). Results indicated that young children answered poorly to the undetermined trials but this performance doubled among the older children. The standard counterfactual questions did not pose great difficulties for either of the two groups. The open counterfactuals were more difficult than the standard ones, with the young group answering correctly in 66% of the cases and the older group on 83% of the times. Although standard counterfactuals were significantly easier for both younger and older children than the undetermined trials and open counterfactuals, no such difference was found between open counterfactuals and undetermined trials. The open counterfactual trials required considering new possibilities. Concluding, the findings do not support the idea that future hypothetical and standard counterfactual tasks require the use of possibilities, but they suggest that open counterfactuals depend on understanding multiple possibilities.

2.3. A different explanation: Counterfactual thinking or basic conditional reasoning?

This section provides the reader with a different interpretation of the evidence presented so far. Rafetseder & Perner (2010) argued that children' success in such large numbers, in Harris et al.'s (1996) study might be, in fact, false positives. As described in the first section, Harris and colleagues presented children with a series of stories. One of the stories was acted out with a puppet and depicted a character Carol, who entered in the house after playing in the mud; Carol forgot taking her shoes off, and the result was muddy prints on the clean carpet. When asked how the floor would be, if Carol had taken her shoes off, most of the children gave the right answer. Rafetseder and Perner (2010) claimed that so many

children answered correctly to this question because they used basic conditional reasoning; this type of reasoning is formed after the model *if x, then y*. Children could have use the knowledge *if* dirty shoes are on, *then* the floor gets dirty; this type of reasoning leads to the right answer, as does counterfactual reasoning.

To support their idea, Rafetseder and Perner (2010) conducted a study including four conditions that were different depending on the number of locations and on their nature. The conditions included: one typical location, two typical locations, one atypical location, and two atypical locations. For example, children heard the following story in the one typical-location condition. A physician, is at the hospital; he receives a phone call to go to the pool and attend little Jacob. He goes from the hospital straight to the swimming pool. Children were asked "what if Jacob hadn't hurt himself, where would the physician be?" The same story is told in the atypical-location condition, only that this time, the physician is in the park when he receives the phone call. If children make use of the basic conditional reasoning, the most probable answer is *hospital* as physicians are associated with hospitals, not parks. Two more complex scenarios were also created. In the 2-typical-locations condition the physician is in the park, he goes to work after sitting in the park where he receives a call to go to the pool and attend on little Jacob. The question "where would the doctor be, if Jacob hadn't hurt himself?" should be answered with the typical location hospital. The 2-atypical-locations condition presented the physician in the park. Here he received the call about little Jacob, he ran to the hospital for his first aid kit and then rushed to the pool. The question "where would the doctor be, if Jacob hadn't hurt himself?" should now lead to the atypical location park. 3- to 4 and 5- to 6-year-olds listened to 4 different stories in all 4 conditions. The 2-atypical-locations condition was proved the most difficult for children. After participants were split in 10 small age groups, the pattern of the counterfactual reasoning showed that 3-and-a-half-year-old

children tended to make typical errors, answering the question "where would the physician be?" with "hospital" and therefore using their general base of knowledge. At 4 years of age children might understand that *if* implies a change, a different location, but most of them answered with the doctor's actual location (reality error). At the age of 5 children hardly made any mistakes in the singular location condition, but tended to answer with the typical location in the 2-atypical-locations condition. Only at the age of 6, children mastered the counterfactual reasoning strategy and solved counterfactual tasks without issues. These changes across the childhood years might be supported by the development of language, working memory and inhibitory skills, and the number of possibilities allowed by each scenario. Only after the age of 5 can children juggle with numerous possibilities (Beck et al., 2006).

To add further to this, another study by Rafetseder, Schwitalla, & Perner (2013) investigated the developmental trajectory of counterfactual thinking by administering counterfactual tasks to 5– and 6-year-olds, but also 9– to 14-year-olds and adults. The stories used in this study had the following structure: two characters sought the same object, there were two possible locations were the object could have been found, each character had access to one and only one of the locations. Participants had to judge where the object would be if one of the characters had come looking for it. The findings of this study suggested that children tend to answers this task by using strategies such as "if one first character comes along, he will take the object with him", without further considering all the aspects of the story. Although children's performance improved with age, only by the age of 12 children engaged in adult-like counterfactual thinking.

These sections presented mixed data referring to the emergence of counterfactuals; while Harris et al. (1996) suggested that 3-year olds do not encounter much difficulty in

answering counterfactuals, other data suggests that counterfactuals still prove difficult at the age of 4 (Beck & Guthrie, 2011; Riggs et al., 1998). Moreover, there are findings suggesting that a complete development of the counterfactual reasoning ability does not take place until the age of 12 (Rafetseder et al., 2013).

2.4. Further development: Counterfactual Emotions.

This section aims to review the developmental literature on the way children understand and experience counterfactual emotions. Regret and relief are two of the earliest developments in terms of counterfactual emotions. Our review will focus on the development of these two emotions.

One of the first studies on counterfactual emotions was conducted by Guttentag and Ferrell (2004) who investigated children's responses to stories describing other people's emotions. In line with the previous literature, Guttentag and Ferrell expected that a highly cognitively mutable event (such as an atypical choice) would cause greater feelings of regret than a typical course of action (Kahneman & Miller, 1986). The participants in their experiment were 5-, 7-, and 9-year-olds, as well as adults. Participants heard 4 stories that consisted of four different types of events: a typical and an atypical event, an act of omission and one of commission. An example of typical/atypical story is the following one: two boys Bob and David have to ride their bikes around a pond to go to school; there are two ways to go to school around the pound, both of them equally short and smooth. Bob always takes the right path to go to school. Today, he took his usual path, but he have not noticed that a tree branch was on the path, he hit the branch, fell of the bike and got hurt. Moreover, he was late for school. David, on the other hand always takes the left path to go to school; however, today he decided for the right path. Unfortunately, he hit the brunch and got hurt, same as Bob.

Participants had to decide which one of the two characters will feel worse. The omission/commission stories followed the same structure but one of the characters acted somehow (e.g. swap a box containing a big prize for one containing a smaller prize, not knowing what the boxes contained), while the second character did not act in a certain manner (e.g.: refused to swap a box containing a small prize, for a second box containing a big prize). 5-year-old children made their decision solely on the outcome suffered by the character in the story; thus, young children considered that both characters felt as bad when the mishap happened, independently of their choices. From the age of 7 onward, on the other hand, the three groups gave similar answers, and found that characters that made an atypical choice and those that committed an action would feel worse than characters that made their typical choice, or did not commit an act. All the other three groups understood the importance that mutability of an event could have on consequent emotions.

Guttentag and Ferrell (Study 3, 2004) also investigated whether children can compare reality with a worse possibility and understand relief. The stories used in this study followed the structure of those used in the study described above, but the characters avoided experiencing a bad outcome by acting typically or atypically, or by doing something or avoiding acting in a certain manner. Two of the stories had a neutral outcome instead of a bad outcome, and two of the stories had a positive outcome instead of a neutral one. Participants in this study were a group of 7-year-olds and adults. The results of this study suggested that unlike adults, children thought both characters would feel the same way, because they experienced the same outcome. Adults, on the other hand found the atypical and the commission situations as generating more relief than the other two situations. Taken together, these results suggest that at the age of 7 children assess regret in an adult like manner; relief might develop later than regret, as by the age of 7 children do not assess relief in the same

way adults do. This lag between regret and relief might be due to the fact that negative outcomes are more likely trigger counterfactual alternatives than positive outcomes (German, 1999).

A possible explanation for why the 5-year-olds in Guttentag and Ferrell's (2004) study do not understand how others feel regret comes from Beck and Crilly (2009) who suggested that children do not understand regret, as by that age they do not really understand multiple possibilities and do not think about counterfactuals as alternatives to reality (see Beck et al., 2006). In their study, Beck and Crilly used two regret stories based on Guttentag and Ferrell (see Bob and David story described above) and acted them out with dolls. At the end of the stories a counterfactual question ("Could David have gone another way?") was added to the emotion question. Beside the regret task, children also completed a counterfactual task similar to that used in Beck et al.'s (2006) study; children were asked either a standard or an open counterfactual question. Results have shown that standard counterfactual questions were the easiest for, 5- and 6-year-olds, followed by open counterfactuals, and by regret tasks. The results of this study suggested that children did not understand regret although they could solve standard counterfactuals, and although they had a decent performance on open counterfactuals. This suggests that understanding multiple alternatives might be necessary but not sufficient in understanding regret.

Ferrell, Guttentag & Gredlein (2009) researched further the age differences in judging other people's counterfactual affective states. The counterfactual emotion task included four different stories that presented two characters that could have experienced either a more negative or a neutral outcome compared with the real outcome, either a more positive or a neutral outcome when compared with the actual outcome. The stories also had an explicit version that made references to the character's emotional assessment of the outcome and an

inexplicit version that simply stated the actual outcome. The findings indicated that whereas most adults judged that the character that could have experience a better outcome would experience more regret than the character for which the two alternatives would have resulted in the same outcome, most children judged that both characters would experience similar feelings. An interesting pattern was observed among the 8-year-olds. When this group received information about the character's judgments, they tended to attribute negative feelings to the character confronted with a better alternative. This study is indicating that children start making adult-like judgments about what might have occurred around the age of 8.

The studies reviewed so far present inconsistent data. While Guttenetag and Ferrell (2004) suggested that children can understand regret in others by the age of 7, Ferrell et al. (2009) suggested that 8-year-olds are understanding regret in others only when extra information is added to the task. These results could be explained through the valence of the outcomes presented in the stories used in each study. In Guttentag and Ferrell's study both characters experienced a negative outcome, while in Ferrell et al.'s study one character suffered a bad outcome, while the other experienced a neutral outcome. If children's counterfactual thoughts are more likely to be triggered by negative outcomes (German, 1999), then children in Guttentag and Ferrell's study were more inclined to give counterfactual interpretations than children in Ferrell et al.'s study.

An addition to this literature was made by Weisberg and Beck (2010) who investigated not only understanding regret and relief in others, but also children's experience of regret and relief. In Experiment 1, 5- to 8-year-olds and adults chose one out of two boxes placed on a table. Each box contained a different number of stickers. After opening their chosen box, participants had to rate how happy they are. They rated again how happy they

were after seeing the content of the alternative unchosen box. On the relief trial participants would have won no stickers had the other box been chosen, whereas on the regret trial the participants would have won more stickers if the alternative box had been chosen. The experience of regret was evident in all age groups and no significant differences were revealed on the regret scores. Nevertheless, there were some differences in the case of relief, with children experiencing relief at 7 years of age. The younger children (5- and 6-year-olds) appear not to differentiate between regret and relief trials. In Experiment 2, children aged 5- to 7- year-old and adults were assigns to either play the game themselves (self condition) or to watch another play (other condition). The self condition replicated Experiment1. The self condition revealed that both 5- to 6-year-olds and 6- to 7-year-olds experienced regret but not relief. Children from both age groups seem not to identify and understand regret or relief in others. Interestingly, children said Arnold the Penguin (other condition) would feel worse in the relief condition, when discovering the unchosen box was empty. Moreover, consistent with previous literature (Roese, 1997; German, 1999) negative events appear to trigger more counterfactual emotions than positive events which may explain why children experience regret earlier that relief.

In a recent study, Weisberg & Beck (2012) investigated the lag between children's experience of regret and relief and the lag in experiencing and understanding these counterfactual emotions. This study improved the methodology of Weisberg & Beck (2010) by offering children a more significant counterfactual outcome, by equalizing the difference between what could have been won and what could have been lost, and by creating a symmetrical scale for regret and relief. Participants aged 4-to-5-year-old, 5-to-6-year-old and 6-to-7-year-old played a card game that meant that participants chose a card and ended with participants either winning less tokens that they could have (regret in winning condition trial),

losing tokens instead of winning (regret in losing condition), winning tokens instead of losing (relief in winning condition) or losing less tokens instead of losing all they could have lost (relief in losing condition). The younger group experienced regret only in the regret in winning condition trial. 5-to 6-year-olds felt regret in both trials, but felt relief only in the relief in the losing condition. It has been suggested that 4-to 5-year-olds, and 5-to 6-year-olds felt regret and relief in the regret in winning trial and relief in the loosing trial as it takes less computational effort to see the loss in the first situation where 2 is directly compared to 8 (Weisberg & Beck, 2012).

The same pattern of regret and relief was found in a second study (Weisberg & Beck, 2012, Study 2) that introduced the illusion of control variable. Same card game was played but this time the cards were either chosen by the participant, by the experimenter, or through throwing a dice. No emotion changes were registered in the "experimenter" condition. This indicated that children experience regret and relief when their personal decision leads to the outcome.

Burns, Riggs, and Beck (2013) have investigated the relationship between executive functioning and regret in children aged 4 to 8. The executive functioning tasks were counting recall (assessing verbal working memory), pictures task (assessing inhibitory control), abstract shapes task (for memory span), and eyes task (assessing spatial inhibitory control and shifting). Regret was assessed in two types of tasks: (1) boxes task - also used in Weisberg and Beck (2010) and (2) a story task based on Guttentag and Ferrell's (2004) story. In line with the other studies children's performance on regret tasks improved across years. About a quarter of the 4- and 5-year-olds showed evidence of feeling regret in the box game, but about three quarters of the 6- and 7-year-olds regretted choosing the box with fewer stickers. A similar pattern was noticed when analyzing how children understand regret in others; only

by the age of 7 children seem to commit less errors in understanding when other people will feel regret. The relationship between executive functions and regret was supported as children's switching ability predicted regret in children; inhibitory control and working memory did not accounted for variance in experiencing regret.

Regret is, perhaps, the most noticeable counterfactual emotion in children. Two approaches can be noticed in the literature: exploring the understanding of regret in others (e.g. Guttentag & Ferrell, 2004) and investigating when children start experiencing regret (Weisberg & Beck, 2010; 2012). Experiencing regret appears to precede understanding regret in others (Weisberg & Beck, 2010; Guttentag & Ferrell, 2004). Counterfactual tasks seem to be easier to solve than counterfactual emotion tasks. Why might this be? Counterfactual statements such as "if I had been chosen the red box, I would have won 8 stickers instead of just 2" are thought to be at the base of regret. Although children can reason counterfactually when prompted, the spontaneous production of counterfactuals might be difficult for preschoolers (Beck, Weisberg, Burns, & Riggs, 2013). Also, as regret seems to be related to executive functions (Burns et al., 2011), it might depend on the late development of such executive skills and therefore it could prove difficult for younger children (Beck et al., 2013).

2.5.Conclusion

Counterfactuals are related to past events and people who engage in counterfactuals, usually generate different worlds and find alternatives to what has actually happened. The question that still remains unanswered is when do children start generating different worlds? Traditional cognitive developmental studies use tasks presenting a real world and ask to infer a counterfactual alternative. Ignoring reality and inferring counterfactuals requires inhibitory

control (Beck, Riggs, & Gorniak, 2009). Counterfactual reasoning plays a role in making inferences from the current state of affairs (Harris, Germans, & Mills, 1996; Roese, 1997), finding alternatives to real world beliefs (Amsel, Trifoni, & Campbell, 2005), learning from mistakes (Roese, 1997).

3. INFERRING REALITY FROM COUNTERFACTUALS

3.1. Abstract

Preschool children find counterfactual tasks challenging. Understanding how children's difficulties with counterfactual reasoning could be reduced is needed to gain an insight into children's generation of counterfactuals. In two studies we explored different aspects of counterfactual thinking in 3-to 5-year-olds, to see why children find counterfactuals difficult and how can we help them improve their performance on counterfactual tasks. 3-to 4-year-olds (Study 1 and 2) and 4-to 5-year-olds (Study 2) found it easier to infer a counterfactual from reality than to infer reality from a counterfactual. We also used an arrow delay manipulation to see if this could support children's counterfactual thinking. Our findings did not support this suggestion. In conclusion, we suggest that (1) the relationship between generating counterfactuals and inferring reality is asymmetrical, (2) the effect of an inhibitory response mode manipulation is more fragile than previously thought, and (3) children in our samples did not find counterfactual tasks trivially easy.

3.2. Introduction

As seen in the previous chapters, counterfactual thinking is pervasive in adults (Roese & Summerville, 2005), but children develop it during early and middle childhood (e.g. Harris et al., 1996; Riggs et al., 1998; German & Nichols, 2003; Beck et al., 2010). While some authors have claimed that counterfactual reasoning is acquired quite early at the age of 3 (Harris et al., 1996; German & Nichols, 2003), other studies did not report evidence of

counterfactual reasoning in such young children (Riggs et al., 1998; Rafetseder & Perner, 2010; Beck, et al., 2010; Beck & Guthrie, 2011). The actual emergence of counterfactual thinking remains controversial. It is generally agreed, though, that counterfactual thinking develops over several years (Beck et al., 2006; Rafetseder et al., 2010; Weisberg & Beck, 2010, 2011).

3.2.1. Counterfactual reasoning and executive demands

Several studies have suggested that development of counterfactual reasoning in children is, at least in part, due to development in executive functions, especially inhibitory control. Inhibitory control is seen as important for intelligent thought as it allows one to suppress any interfering elements (Carlson, Moses, & Hix, 1998; Hala & Russell, 2001) in order to reach an aim. The frontal lobes, which are regarded as the biological base of the inhibitory processes, undergo extended development and maturation during adolescence (Dumontheil, Burgess, & Blakemore, 2008; Dumontheil, in press). These changes that occur during adolescence are smaller than those happening during childhood, but they are essential for acquiring higher cognitive skills (Dumontheil, in press). The lack of maturity of the frontal lobes might account for certain inhibitory difficulties among children (Niggs, 2000). Most explanations regarding inhibitory control refer to the children's difficulty in ignoring an incorrect strong automatic or prepotent response. Simpson, Riggs, Beck, Gorniak, Wu, & Diamond (2011) suggested that a prepotent response is created when a response seems valid for a task. Thus, as the real and the counterfactual world are similar, answering with the real event to a counterfactual question might seem valid to children. Although these claims were made about laboratory tasks, they might be translated to real life counterfactual thinking as well.

Counterfactuals involve creating and bearing in mind not only the real world, but also an alternative world (Guajardo & Turley-Ames, 2004), therefore in a counterfactual task, children have not only to inhibit a prepotent response, but also to shift between the real world and the imagined alternative; thus, a counterfactual task might not tap a single executive function. Indeed, there is evidence suggesting that working memory and cognitive flexibility are significant predictors for success on counterfactual tasks. These executive functions accounted for 16% of the variance in children's performance on counterfactual tasks (Guajardo, Parker & Turley-Ames, 2009). Also, inhibitory control (Drayton et al., 2011), working memory (Guajardo et al., 2009; Drayton et al., 2011) and cognitive flexibility (Guajardo et al., 2009) significantly mediate the relationship between performance on counterfactual and false belief tasks. Beck, Riggs, & Gorniak (2009) have also investigated the relationship between working memory, inhibitory control, verbal ability, and counterfactual reasoning tasks in 3- and 4-year-olds. Whereas no relationship was found between working memory and counterfactual tasks, language ability and inhibitory control contributed to predicting performance on counterfactual tasks. However, these findings cannot explain any causal relation between executive functions and performance on counterfactuals. Only a direct manipulation of inhibitory demands on the counterfactual tasks could show how children's performance is affected.

3.2.2. Supporting children's inferences

In our two studies, we used a new version of a counterfactual task which we predicted would be easier for young children. In the new task the child hears a counterfactual statement and has to infer reality. There are two reasons why this might be easier for young children compared to inferring a counterfactual world from reality: first, there may be reduced

inhibitory demands as the child does not have to ignore reality; second, the question that is asked is grammatically simpler than that in standard counterfactual tasks (i.e. reduced language demands).

Standard counterfactual studies looking at children's generative skills presented participants with reality and asked them to think about what could have happened differently (e.g. Riggs et al., 1998; German & Nichols, 2003). Ignoring reality in order to speculate about a counterfactual makes inhibitory demands for 3- to 4-year-olds (Beck et al., 2009; Beck et al., 2011). Therefore, it might be easier for children to solve tasks that require inferring reality from a counterfactual, especially considering that their encounters with counterfactuals in real life are more likely to be phrased in this reverse direction (e.g. If only you had remembered your umbrella, you wouldn't be getting so wet). This present investigation considered possible world generation in the reverse direction by inferring reality from a counterfactual.

Language is moderately associated with measures of inhibitory control and working memory in children (Beck et al., 2009). Moreover, language is an essential tool so that children can comprehend and respond to a counterfactual task and to verbalize thoughts and alternative possibilities (Guajardo et al., 2009), and also to build self regulatory strategies (Hughes, 1996). Also, language is related to counterfactuals, as together with age it has been found to account for 50% for the variance in counterfactual tasks performed by children (Guajardo et al., 2009). It has been suggested that counterfactual reasoning can be unnatural even among adults if they are not exposed to a number of linguistic and cultural forms (Schribner, 1997 in Harris, German, & Mills, 1996).

Counterfactuals are usually expressed through the subjunctive, which is not an early grammar form to be understood and used by children. Perner and his colleagues (2004) tested whether using the indicative in a set of simple partial-counterfactual conditionals

(counterfactuals that were formed of a counterfactual antecedent and a future-hypothetical consequence – this structure is permitted by the German language) or the subjunctive for the counterfactual conditionals used in the simple transport scenario (see Figure 1, section 2.2.1.) might influence children's performance; no difference between these two conditions was found. However, the linguistic formulation of counterfactuals differ from language to language, therefore Perner's et al. findings refer strictly to German language and we might hesitate to generalise to other languages. In our new version of the task, where children were required to generate reality given a counterfactual statement, the test question was phrased using the indicative. We hoped that this would place fewer demands on children's comprehension of the task.

Based on these premises, Beck & Sunda (unpublished pilot study, 2012) tested 41 3- to 4-year-olds and 41 4- to 5-year-olds in four reality-to-counterfactual trials (for example, in a story where John drops a vase when moving it and breaks it, the reality-to-counterfactual question was: What if John had not dropped the vase, would it be broken?) and on four counterfactual-to-reality trials (Mum says: Oh no! If you had not dropped the vase, it would not be broken. Is the vase broken?) The older children found the counterfactual-to-reality task, which used an indicative question, easier giving more correct answers (M = 3.49) than for the reality-to-counterfactual trial (M = 3.02). Although older children found generating the reality from a counterfactual as less problematic, younger children found generating alternative and real worlds equally challenging.

3.2.3. Supporting children's reasoning with alternative modes of response

In our studies we sought to manipulate the inhibitory control demands in the counterfactual tasks. We did this by using a response mode manipulation that has been employed by other researchers. The response mode manipulation (pointing with an arrow rather than the finger) has been argued to reduce prepotent or impulsive responding. During infancy children are prompted to point with their finger, and very often they are rewarded when they point correctly. For instance, Mum says "car", the child points to a toy car there is nearby and is rewarded by their Mum for answering correctly. Pointing could result in learned responses that might prove difficult to inhibit. In Carlson et al. (1998) children needed to deceive another person about the location of a ball: there were two boxes, one of which was known by the child as containing the ball; the child had to deceive the other person by pointing at the empty box either with their finger, with a card arrow, or by placing a picture of the ball on top of the empty box. 3-year-olds did not manage to deceive the other person when they pointed with their finger. Their performance improved significantly when they pointed with an arrow, or when they placed the picture on top of one of the boxes. Carlson and colleagues (1998) argued that deceiving by pointing with a finger is difficult as pointing to a veridical location or object was rewarded in the past. Inhibiting such a reinforced response will pose great difficulty. On the other hand, pointing with an arrow, or placing a picture at one location are not related to any previous responses or rewards; this could in turn explain why children were better at deceiving in these conditions.

The arrow manipulation was also used in the context of counterfactual tasks. Beck, Caroll, Brunsdon, & Gryg (2011) tested whether executive demands hinder the understanding of counterfactuals in preschoolers. They conducted two experiments with children from two age groups (3- and 4-year-olds and 4- and 5-year-olds) and the results have shown that

children were more likely to give the correct answer to counterfactual tasks when using an unconventional response mode (an arrow) or when they had to delay their response (wait for a doll to finish sliding on a slide). The arrow manipulation was used in previous false belief studies (see above Carlson et al., 1998); Beck and colleagues sought whether the arrow manipulation might reduce the cognitive demands of a counterfactual task; they also used a delay manipulation (based on Diamond, Kirkham & Amso, 2002), which also might reduce cognitive demands and impulsive responses elicited by counterfactual tasks. Their first experiment used two standard counterfactual stories and two syllogisms and compared only the arrow manipulation with a control finger pointing condition. The authors found that using an arrow helped both age groups perform better on both types of tasks. The second experiment was run in order to establish why using an arrow is helpful. Beck et al. (2011) argued that using a nonconventional response mode might help children because children inhibit an impulsive response, not a habitual one. Beside the use of the arrow, the authors included a second manipulation, a delay; children were told they have to wait for a doll to come down a slide before giving any answers. Both manipulations (the arrow and the slide) improved children's performance, i.e. children gave more correct answers in the experimental conditions that they did in the control condition. While pointing with an arrow is related to pointing and thus it might be said that pointing with an alternative item is inhibiting the pre-learned pointing response, no such connection could be made between waiting for the doll to slide and pointing with the finger. The authors suggested that the arrow and the delay manipulation might allow children to overcome impulsive answers by slowing them down.

Interestingly, the arrow response mode manipulation does not always lead to improved performance. Carroll, Riggs, Apperly, Graham, & Geoghegan (2012) checked whether alternative modes of response influence 3- and 4-year-olds' performance on false belief,

inhibitory control, and strategic reasoning tasks. For each task, participants responded by pointing with their finger or by using a rotating arrow. Only children's performance on the strategic reasoning task was improved by the arrow manipulation; the false belief and inhibitory control task did not benefit from this manipulation. These results suggested that manipulating the response mode might help children with developing aspects of a reasoning strategy, rather than reducing inhibitory demands (also see Carroll, Apperly, & Riggs, 2007).

3.2.4. Aims of the current studies

The current studies investigated whether an alternative way of pointing (by using an arrow) will reduce the inhibitory demands of a counterfactual task (Beck et al., 2011; Beck et al., 2009; Carlson et al., 1988) and lead to improvements in children's performance. Previous research suggested that children's performance on deceiving tasks (Carlson et al., 1998), counterfactual conditionals and syllogisms (Beck et al., 2011) and strategic reasoning tasks (Carroll et al., 2007; Carroll et al., 2012) can be substantially improved by the response means (e.g. pointing with an arrow; placing a marker; additional wording). Also, we sought to discover whether hearing a counterfactual and concluding the real outcome from it will place less executive demands on children's reasoning, than inferring the counterfactual antecedent from a given outcome (see Beck & Sunda, 2012).

3.3. Study 1

3.3.1. Methods

3.3.1.1. Participants

The sample consisted of twenty-two pre-school children. The age range was between 2 years and 9 months and 4 years and 3 months, with a mean age of 3 years and 4 months (SD =

5.41). Children were recruited from two preschools in Worcester (England) and a nursery in Birmingham (England). All institutions were serving a working-class population of the United Kingdom (for example consent forms see Appendix 1). The distribution across gender and ethnicity was at follows: 68.2% boys and respectively 61.9% of the participants were White, 33.3% Black and 4.8% of other or unknown ethnicity.

All participants spoke English as their first language or were deemed by their teachers as competent in English.

3.3.1.2. Materials

We developed two warm-up and four experimental illustrated stories (See Appendix 2). For each of the four stories included in this study there was a standard reality-to-counterfactual version and a new counterfactual-to-reality version. Each story included 2 pictures presenting the main character and a thing or place and 2 pictures showing the two possible answers of the story. This illustrated answer format was used in order to eliminate the problems that giving a solely verbal answer might pose. We wanted to make sure that children understood the possible results: one picture depicted reality (e.g. picture of a broken vase), while the other was depicting the counterfactual outcome (e.g. picture of a vase).

Children gave the response to these counterfactual stories either by pointing with their finger, or with a cardboard arrow (of approximately 10 cm).

3.3.1.3. Design

Each participant was given two warm-up stories. For example, children saw the picture of Katie and were told she liked green fruits; this picture was followed by a picture of a green apple or some red cherries, children had to indicate with their finger, or with the arrow which is Katie's preferred fruit. The four counterfactual stories were told in the following

order: (1) broken vase, (2) forgotten present, (3) lost dog, and (4) ripped page. Two of these stories were told in the reality-to-counterfactual version (RtC) and two in the counterfactual-to-reality version (CtR). For two of these stories, children pointed with their finger, and for the other two with the arrow. As a result children answered an RtC story by using an arrow, and the other story by using their finger; the same was true for the CtR stories. The order in which these versions were given was fixed. Participants 1 and 2 started in the finger pointing condition, followed by the arrow condition: the first one received the CtR trial first, while the later received the RtC trials first in both conditions. Participants 3 and 4 received the stories in the arrow condition first and the ones in the finger pointing condition second. To avoid answer biases, the order of the pictures illustrating the right answers and of those illustrating the wrong answers was arranged so the right answer would not be always on the right hand side. For each participant the right answer was always placed twice in the left and twice in the right hand side.

3.3.1.4. Procedure

The test was conducted in a quiet area of the school and took no more than 10 minutes. Each participant was first told a warm-up story to check whether pointing with their finger or with an arrow would raise any difficulties. Every participant listened to two stories in the first response mode (either finger or arrow) followed by a second warm up story to help them shift in the next response mode, and the final two stories.

For example, in one of the stories a character, John, was at home and tried to help his mum by moving her vase from the table to the windowsill. The children in the RtC version heard “John picks up the vase…but then, he drops the vase and breaks it. His mum comes in and says, Oh no!” And then the subjunctive question follows: “What if John had not dropped the vase, what would the vase look like? Would the vase be in one piece or would it be

broken?" In the CtR they heard the same story but phrased from counterfactual to reality ("His mum comes in and says, 'Oh no, if you had not dropped the vase, it would not be broken!") and then an indicative question follows: "What happened, what does the vase look like? Is the vase all in one piece or is the vase broken?" In this condition children did not explicitly hear that the vase was broken, but they had to infer it from Mum's statement.

All of the other stories were structured in the same way. In the forgotten present, a girl goes to her best friend birthday party, but she has left her friend's present at home. In the lost dog story, a character comes home and because he has forgotten to close the door behind him, his dog runs outside. The last story presents a girl reading a story book and ripping one of the pages as she had turned it too quickly.

3.3.2. Results and Discussion

Warm-up trials

Children's correct answers scored 1, while the incorrect answers received a score of 0. The warm-up questions were answered quite accurately by the participants. 70% of the participants answered correctly on their first attempt, and all of them answered correctly after the experimenter explained the task to them once more. No participants' scores were removed from the database. Children had no difficulties in using the arrow.

Counterfactual questions

First, the two manipulations of this experiment (counterfactual-to-reality vs. reality-to-counterfactual and pointing with finger vs. pointing with arrow) were combined and resulted in four different conditions: CtR finger, RtC finger, CtR arrow and RtC arrow. The data were analysed in two different ways. First, we conducted non-parametric McNemar tests to contrast

different individual trials. Second, we looked for more general effects of our manipulations, using paired t-tests.

Four McNemar tests were run, to make the logical comparisons between the four conditions presented above i.e. CtR finger, RtC finger, CtR arrow, RtC arrow. The four comparisons did not yield any significant results (lowest $p < .143$) (See Table 1). This suggested that participants did not benefit more from one condition compared to the others.

Table 1. Frequencies of correct answers given by participants across RtC finger, CtR finger, RtC arrow, and CtR arrow conditions.

Trial type	Right
RtC finger	12
CtR finger	14
RtC arrow	9
CtR arrow	16

Second, to confirm there are no differences between our main manipulations, we ran two paird t-tests. The first paired t-test evaluated the impact of CtR and RtC trials on children's performance to a counterfactual task, while the second paired t-test evaluated the impact of the response modes: pointing with an arrow and pointing with the finger on counterfactual tasks scores.

Results suggested that although children did not discriminate between the two RtC and CtR trials ($t(43) = 1.71$, $p < .095$), there was a pattern, with children finding the CtR tasks (M = .68) easier than the RtC ones (M = .48). The arrow manipulation did not affect children's performance ($p < .400$).

In this study we manipulated aspects of counterfactual tasks that might help children overcome the difficulty of passing such tasks. It was expected that a response mode manipulation might help children improve their performance on counterfactual tasks, as these alternative ways of response could have reduced children's impulsivity (Beck et al., 2011) or reduce the prepotency of habitual responses (Carlson et al., 1998). Despite suggestions in the literature (Beck et al., 2011; Carlson et al., 1998), the response mode manipulation did not result in any improvements to children's performance on counterfactual tasks.

Another manipulation we were interested in was the question type. We suggested that it might be easier for children to infer what happened from a counterfactual, than to infer what could have happened from reality. Although children did not discriminate between the two types of questions, there was a slight hint that children found the counterfactual-to-reality tasks (M = .68) easier than the reality-to-counterfactual stories (M = .48). This is consistent with Beck & Sunda's (2012) findings. Beck & Sunda (2012) found that 4-to 5-year-olds gave significantly more correct answers in the CtR condition than in the RtC; and a trend in the same direction was observed in the 3-year-old children. The same pattern was observed in our 3-year-old group. Perhaps, this did not reach significance, as the sample was too small. Also our sample was formed from mainly 3-year-olds. There is little evidence of any counterfactual reasoning before the age of 3 (Riggs et al., 1998; Beck & Guthrie, 2011; Rafetseder et al., 2010). A further study is needed in order to compare this age group with another age group.

3.4. Study 2

This study used the same materials, design and procedure as in Study 1, but the samples of children responding to the tasks were older as well as of the same age as in the previous study.

3.4.1. Methods

3.4.1.1. Participants

The sample of this study was formed of 25 boys and 25 girls with ages ranging from 2 years 7 months to 6 years 3 months (M = 53.78 months, SD = 10.12 months). Ninety per cent of the children were Romanian (N = 45), and the remaining were Romani.

The participants were almost equally divided into a younger group (14 boys, 10 girls) with age ranges between 31 and 53 months (M = 45.25, SD = 5.55) and an older group (11 boys, 15 girls) ranging between 54 and 75 months (M = 61.65, SD = 6.17).

Children were tested in four preschools in Abrud and Roșia Montană, Romania, institutions serving a middle-class population.

3.4.1.2. Materials

We used the same materials as for study 1: two warm-up and four experimental illustrated stories (See Appendix 2). All the stories used in study 1, in each version, were translated by the researcher from English to Romanian, and then back to English by a blinded translator. No major differences could be observed between the original version and the translated one. The arrow used in Study 1 was also used for this study.

3.4.1.3. Design

For this study, we used the same repeated measures design. Each participant was given a warm-up story followed by the (1) broken vase and (2) forgotten present stories. The second warm-up story was administered, followed by the (3) lost dog, and (4) ripped page stories.

3.4.1.4. Procedure

The test was conducted in a quiet area of the school and took about 8 minutes. Each participant was told first a warm-up story to check whether pointing with their finger or with an arrow will raise any difficulties. Every participant then listened to two stories in the first response mode they were doing (either finger or arrow) followed by a second warm up story (that was supposed to help them shift in the next response mode), and by the final two stories. A child received one counterfactual-to-reality and one reality-to-counterfactual story in the pointing response mode, as well as in the arrow mode.

3.4.2. Results and Discussion

Warm-up trials

This experiment had two warm-up questions, one asked before starting the testing and one asked when changing the response mode.

Children had some difficulties in answering these questions with only 54% of them giving two correct answers, 38% giving one correct answer and the remaining 8% giving two wrong answers. When split in age groups: the young children had more difficulties, 16.7% giving no right answers and only 37% answering both warm-up questions correctly. All older participants gave at least one right answer, with 69.2% of them answering both questions correctly. When further analysed, the first warm-up question "This is Katie. She likes green fruits. Which one does she like? Does she like the apple or does she like the cherries?" seemed to raise the most difficulties for both groups (41% of the young participants and 23.1% of the older participants answering incorrectly) than the second warm-up trial "Do you remember Katie? She likes green fruits. Which one does she like? Does she like the banana or

does she like the grapes?" (37.5% of the young participants and 7.7% of the older ones gave the wrong answer).

However, no participants were excluded from the sample, as all children answered correctly after the experimenter corrected the wrong answers and explained the task again. This pattern of results could have appeared because children tended to answer with what they liked instead of what Katie liked. Also, this might have happened because the children needed the experimenter's further explanation to understand the task.

Reality-to-counterfactual vs. counterfactual-to-reality trial

As in Study 1, the two manipulations of this experiment (counterfactual-to-reality vs. reality-to-counterfactual and pointing with finger vs. pointing with arrow) resulted in four different conditions: CtR finger, RtC finger, CtR arrow and RtC arrow. The data were analysed in two different ways. First, we conducted non-parametric McNemar tests to contrast different individual trials. Second, we looked for more general effects of our manipulations, age and any interactions using ANOVA.

In order to find out how much variation there was between these four types, we ran four McNemar analyses. We compared four pairs: CtR finger vs. RtC finger, CtR finger vs. CtR arrow, CtR arrow vs. RtC arrow, and RtC arrow vs. RtC finger. There were no significant differences observed in scores for three of these pairs (See Table 2), but there was a significant difference between the conditions CtR arrow and RtC arrow (p <.023), participants in the CtR arrow condition giving significantly more correct answers (82.0%) than those in RtC arrow trial (58.0%). Therefore, children did better when they were in the arrow pointing mode of the new counterfactual-to-reality story than they were pointing with an arrow in the standard counterfactual story.

We repeated the McNemar analyses for the four pairs listed above, after splitting the data in two age groups: young and old (see Table 2). The only significant results was that the younger group using the arrow performed better in the CtR version (p <.039) giving more correct answers (83.3%) than in the RtC version (50.0%). No other comparisons were significant for the young or the old group (lowest p < .210).

Table 2. Frequencies of correct and incorrect answers in the different conditions where F stands for finger and A for arrow

Trials	Older group (N = 24)		Young group (N = 26)	
	Incorrect answers	Correct answers	Incorrect answers	Correct Answers
CtR F	6	18	8	18
CtR A	4	20	5	21
RtC A	8	16	13	13
RtC F	6	18	14	12

A mixed ANOVA was conducted to assess the impact that using CtR and RtC formulations for counterfactual trials would have on 3-to 5-year-olds. The purpose of this analysis was to check whether children's responses to counterfactual tasks could be influenced by the way the tasks are formulated, or by their age. We summed scores from each child on the CtR trials and on the RtC trials, so that each child had a score out of two for each condition. There was a main effect found for question type F (1, 48) = 6.35, p < .015, η^2= .117. Children found CtR trials easier (M = 1.53) than the RtC trials (M = 1.17). Performance improved with age F (1, 48) = 4.447, p <. 04, η^2 = 0.85, (younger children M = 1.2, older children M = 1.5). There was no significant interaction between the trial type and the age group, F (1, 48) = 2.15, p < .14, η^2= .04.

A similar analysis was conducted in order to compare between the response modes for the two age groups. There was not a significant main effect found for response mode (F (1, 48) = .803, $p < .37$, $\eta^2 = .016$). Also, no significant interaction was found between the response mode and age (F (1, 48) = 2.86, $p < .09$, $\eta^2 = .056$). As for the previous ANOVA, there was a significant difference in the performance of the two age groups $F(1, 48) = 4.47$, $p < .04$, $\eta^2 = .085$.

This study suggests that the relationship between counterfactuals and reality is asymmetrical. Children found generating reality from a counterfactual less difficult than the reverse. This pattern was most pronounced for the younger group, who showed an improvement in performance on the CtR tasks, compared to RtC tasks in our non-parametric tests. Our analyses suggest that the response mode had no impact on children's performance.

3.5. General Discussion

Previous data suggested that children's difficulty in answering counterfactual tasks might result from poor inhibitory control (Beck et al., 2009), resulting in expression of prepotent habitual responses (Carlson et al., 1998) or of impulsive responses (Beck et al., 2011). It was also possible that language might also influence the way children understand counterfactuals (Beck et al., 2009, Beck et al., 2006). In two studies we manipulated aspects of counterfactual tasks that could affect children's performance on such tasks. These aspects were the type of question (i.e. a language demand; and also potentially an inhibitory control demand) and the response mode (i.e. affecting an executive function demand).

In Study 1, a group of 3-to 4-year-olds received four counterfactual stories in 4 different conditions. The conditions referred to both the question type and the response mode.

The question type manipulated the way children had to think counterfactually. In one condition children received the standard task: a series of events was presented, a mishap happened and children had to think how things could have turned out differently. In the new condition, children heard the same series of events, but the mishap was not presented explicitly but as part of the subjunctive statement (e.g. If you had not dropped the vase, it wouldn't be broken); children had to infer what actually happened from the subjunctive statement. The response mode consisted of the way children answered to the questions: they could have either pointed with their finger at the pictures portraying the two different outcomes, or pointed with an arrow. Study 2 used the same conditions and materials, but this time two different age groups participated to the experiment.

Based on the results of Beck et al. (2011), we hypothesized that children's performance would improve when they pointed with an arrow. Based on pilot work by Beck & Sunda (2012) we also hypothesized that performance would be better in the inferring reality from a counterfactual condition compared to the standard conditions. Study 1 had no significant results: therefore children did not seem to benefit from either of these manipulations; however, there was a suggestion that inferring reality from a counterfactual was done more easily than inferring the counterfactual from the reality. Study 2 revealed that children performed better in the CtR than in the RtC trials; there was a suggestion in our nonparametric analysis that the younger group seem to benefit more than the older group from this manipulation. Overall, children performed similarly in the arrow and finger conditions.

Our response mode manipulation did not yield the same significant results as other studies had. Beck et al. (2011) found in a first experiment that 3-to 5-year-olds improved their answers when pointing with an arrow instead of a finger; however, the authors did not replicate the same findings in a second experiment, when only the 3-to 4-year-olds benefitted

from the arrow manipulation. Our lack of any effect of response mode may reflect the fact that the arrow only affects children in a narrow age range. The younger children in this study ranged in age from 2 years and 7 months to 4 years and 5 months, whereas the youngest children in Beck et al.'s study were 3 years and 4 months. However, making comparisons between samples from different studies is difficult because of the differences between the samples of participants.

The effect of response mode manipulations varies across different tasks. Carlson and colleagues (1998) found that children deceived more often when pointing with an arrow or when placing a marker on top of the wrong location than they did when they answered by finger pointing. The authors suggested that children are helped by the new alternative response modes because they are inhibiting the pre-learned and reinforced response of pointing. Indeed, pointing is commonly used by young children and rewarded by the children's parents. This explanation does not fit neatly with our finding that there was no effect of response mode on our sample.

Carroll et al. (2012) found that while using an arrow will improve children's performance to a task where children have to deceive the experimenter and point to the empty box out of two boxes, this manipulation did not improve children's performance on an Unexpected Transfer task or on a Stroop-like task. These findings do not support the view that a nonstandard response mode reduces the inhibitory demands. These authors continued their research by giving children the Windows task in the finger and arrow condition, but also in a mixed condition where children used the arrow for half of the responses and their finger for the other half. Interestingly, it was found that both using an arrow and a mixed response mode improved children's performance on the Window task. Taken together, the results of this study suggest that using an arrow might actually not influence the inhibitory demands of the

task, but perhaps it supports aspects of children's reasoning by delaying an immediate response. In our study, children did not benefit from using an arrow as a response mode for a counterfactual task. These results were, thus, in line with Carroll et al.'s findings regarding the false belief and inhibitory control task. False belief tasks as well as counterfactual tasks make inhibitory demands on children's reasoning process. Both tasks require children to inhibit what they know to be true. Perhaps, inhibitory demands on the counterfactual tasks used in our studies were too difficult to be overcome by our participants. However, one of the few studies on counterfactuals and alternative ways of responding did support the use of different response modes, other than finger pointing (Beck et al., 2011). Beck et al. (2011) suggested that using an arrow might help because it prevents an impulsive response, instead of inhibiting a pre-learned response. It remains unclear why these studies did not replicate past findings, but one possible explanation could be the content of the counterfactual tasks used. Whereas Beck et al. (2011) used counterfactual tasks that involved a location change, 3 out of 4 of our tasks involved a change of state (e.g. broken/unbroken; ripped/whole). It is possible that pointing to a location might require more inhibitory control than making a response regarding a state.

Although there are other challenges in counterfactual thinking than inhibitory control, perhaps this might be the most salient in the case of young children. For example, future hypothetical trials and counterfactual trials require the same response, but usually future hypothetical questions are answered more easily by preschoolers than the counterfactual questions (Riggs et al., 1998; Perner et al., 2004; Beck et al., 2006). Unlike future hypotheticals, counterfactual questions are based on false antecedents and the events they are referring to contradict what actually happened. Future hypothetical questions are different, because the truth of the events presented remains indeterminate, as the events have not

happened yet. Therefore, children do not have to inhibit answering with what they know as true, at the moment, when answering future hypotheticals, but they have to do so when reasoning counterfactually. Also, the syntax and morphology of the future hypothetical conditionals might be easier to understand for children, as children are more likely to encounter forms such as "if it will rain, you will get wet" than "if it hadn't had rained, you wouldn't have got wet." As in the case of future hypotheticals, the grammar used in our new question type condition was simpler than in the standard counterfactual question.

We expected children to be more familiar with inferring reality from counterfactuals as many parents tend to use this type of counterfactuals. How many times did we hear as children "if you hadn't been running, you wouldn't have fallen over and you wouldn't have been hurt", "if you hadn't been naughty, I would have let you go out and play", or so many others similar formulations? Not only is the wording of a standard counterfactual less common among children, but it also might require more inhibitory control as children have to ignore reality in order to speculate about the counterfactual events and also about the counterfactual outcomes. Children seemed to benefit from this manipulation. Although in Study 1 3-to 4-year-olds only showed a pattern of performing better when reality was not explicit, than when they had to speculate about counterfactuals, in Study 2 there was improved performance when inferring reality from a counterfactual. Overall, children differentiated between these two types of questions, and found the standard task more difficult than the new task. This difference was most pronounced for the 3-to 4-year-olds than for the 4-to 5-year-olds. These findings are similar to Beck & Sunda's (2012) pilot results.

Inferring reality from a counterfactual might prove easier for children than the reverse, not only because it is more commonly met by children during their childhoods, but also because it might require less executive demands. Understanding conditionals of any sorts

requires holding in mind different possibilities (Santamaria, Espino, & Byrne, 2005; Beck et al., 2006). Inferring reality from a counterfactual might ease this process by reducing these demands in the way that although participants in the CtR condition have to hold the same number of counterfactual possibilities in mind, as participants in the RtC condition, the former do not have to remember also the actual events, as reality has to be concluded from the possibilities held in mind. Moreover, participants in the CtR version do not have to remember the real events that are conflicting what might have happened instead. Inhibitory control is related to counterfactual tasks and predicts them even when other variables are controlled for (Beck et al., 2009). Inferring the reality from a counterfactual makes, perhaps, less inhibitory demands on children's cognitive abilities.

Our findings suggest that children's counterfactual reasoning can be supported by using CtR trials, instead of standard RtC trials. CtR trials might prove useful in tapping early counterfactual reasoning. The difference between children's performance on CtR trials compared to RtC trials, suggests that, despite previous claims in the literature (Harris et al., 1996; Harris' 1997), counterfactual reasoning it is not trivially easy for children. 3-to 5-year-olds find counterfactuals challenging; counterfactuals develop over a prolonged period of time (Beck & Riggs, 2014; Beck et al., 2011; Beck & Guthrie, 2011) and might depend on a set of other cognitive processes (i.e.: such as executive functioning; understanding specific grammatical constructions).

4. SUPPORTING CHILDREN'S PERFORMANCE ON DISCRIMINATING TRIALS WITH ADDITIONAL WORDING

4.1. Abstract

One of the first claims regarding children's capacity of reasoning counterfactually was made by Harris, German, & Mills (1996). Their stories were formed of simple causal sequences (e.g. Carol soils the clean floor with her dirty shoes), and 3-year-olds encountered no difficulties in giving the right answer to the counterfactual question "What if Carol had taken her shoes off. Would the floor be dirty?" In a recent study, Rafetseder, Schwitalla, & Perner (2013) used scenarios (based on Harris et al., 1996) in which two characters soiled the floor with their dirty shoes. Children's performance dropped dramatically when they had to judge that the floor will stay dirty if (only) one of the two characters took their shoes off. Based on these two-character scenarios, or other similarly complex scenarios (Rafetseder et al., 2010; Rafetseder & Perner, 2010), Rafetseder and colleagues (2013) suggested that children cannot employ a counterfactual reasoning strategy until after the age of 12. An alternative possibility was that children might misunderstand the implications of the question in Rafetseder's new scenario. The current study investigated whether 5-to 7-year-olds could improve their performance on two-character counterfactual stories if we include the word *just* in the question ("What if *just* Carol had taken her shoes off. Would the floor be dirty?"). Our results suggested that although children found the new just version more difficult than the Harris version, they found it easier than the Rafetseder version. This supports the idea that the

complexity of the scenario in the Rafetseder version makes additional demands on children's reasoning and, perhaps, working memory.

4.2. Introduction

4.2.1. Can young children reason counterfactually?

Although counterfactual thinking is difficult for young children, some researchers have claimed that even children as young as 2 (Harris, 1997) or 3 (Harris et al., 1996; German & Nichols, 2003) can reason counterfactually. More recent evidence supports the idea that only at and after the age of 4 children could answer counterfactual questions correctly, and it suggests that preschoolers' poor performance improves during middle childhood (Beck, Riggs, & Gorniak, 2010; Beck et al., 2006; Weisberg & Beck, 2010). In the current experiment we sought to understand why some counterfactual tasks might prove so difficult for children.

Previous research has presented inconsistent data. One of the first studies by Harris and colleagues (1996) asked children to consider how things would have been different had the causal sequence taken a different course. For instance, one of the stories presented Carol playing outside in the mud. The second event was Carol walking on a clean floor with her dirty shoes on. The outcome was a dirty floor. Children were asked to consider what outcome could have been obtained if one of the elements of the sequence had been changed (e.g. Carol had taken her shoes off). Harris et al. claimed that children have to engage in counterfactual thinking to obtain the right answer to the question, as they had to generate a contrary-to-fact world where Carol had actually taken her shoes off. 3-to 4-year-olds and 4-to 5-year-olds participated to this experiment. Children from both age groups performed well on the test

questions; 69% of the younger children and 85% of the older children gave at least 3 correct answers out of 4. This suggested that even 3-year-olds can engage in counterfactual thinking and consider counterfactual antecedents so that a certain outcome could be prevented.

In contrast, Riggs et al. (1998) found that 3-year-olds tend to commit reality errors and that only around half of the 4-year-olds gave correct answers to the counterfactual stories used during their experiment. Children's relatively poor performance in the counterfactual condition could not have arisen as a symptom of poor conditional reasoning, or of children's inability of generating new alternatives, given that children found future hypotheticals, which made comparable reasoning and generative demands, easier than counterfactuals at the age of 4 (Riggs et al., 1998; Perner et al., 2004; Beck et al., 2006).

The difference between the results found by Harris et al. and Riggs et al. could be explained by different levels of complexity of the scenarios: in the first study a simple sequence of events led to a mishap and the mishap led to an unfavorable result, but in the later study the scenario had more events and the mishap could not be related directly to one of the protagonists. Perner et al. (2004) found that a complex travelling scenario proved to be more challenging in a counterfactual task than a simple one. German and Nichols (2003) found that a long causal sequence is more difficult to solve than a short causal sentence (although this finding was not replicated by Beck et al., 2010). Complex scenarios may make memory demands and thus, be challenging for young children. However, there is mixed evidence on the relationship between working memory and counterfactual reasoning (Beck et al., 2009; Guajardo et al., 2009).

4.2.2. Counterfactual reasoning or basic conditional reasoning?

Another account proposes that very young children that performed very well on the Harris type tasks might, in fact, have used their knowledge about the world instead of using a counterfactual reasoning skill (Beck et al., 2006); or they might have used a type of conditional reasoning that does not involve counterfactual thinking (Rafetseder et al., 2010; Rafetseder et al.,2013). Rafetseder and her colleagues (2010; 2013) argue that we can only be sure of seeing genuine counterfactual reasoning in children when participants could get to the right answer without using any other strategy than reasoning counterfactually. Rafetseder et al. argued that many of the past investigations on counterfactual thinking in children had contradictory or unreliable results because some of the counterfactual tasks could have been solved by using a conditional reasoning strategy instead of a counterfactual strategy (Rafetseder et al., 2010; Rafetseder & Perner, 2010). Let's consider, for example, the sequence "Carol entered the room with her muddy shoes on. Now the floor is dirty." This sequence is followed by a subjunctive question "What if Carol had taken her shoes off, would the floor be dirty or clean?" It was suggested that using a basic conditional reasoning strategy of the type "if x, then y" would lead to the right answer. Children have the general knowledge that dirty shoes are not allowed on a clean floor, as dirty footprints will appear on that floor. Using the strategy "if x then y children" could answer the subjunctive question written above not by imagining an alternative world where Carol would have taken her shoes off, but by thinking that "if there are no shoes, then the floor must stay clean."

Rafetseder et al. (2013) investigated how 5-to 6-year-olds, 7-to 10-year-olds, 13-to 15-year-olds, and adults answered a counterfactual task that could be solved using a conditional reasoning strategy, compared to a task that required counterfactual reasoning to be solved. The stories used were based on those of Harris et al.'s (1996), but one of the versions could be

answered correctly only by using counterfactual reasoning; this new version is a two-protagonists, discriminating version. In the new version, Susi walked with her dirty shoes on the clean floor making footmarks all over. Right after her, Max walked with his dirty shoes on the same floor. If children were tempted to use the "if X then Y" strategy when answering the experimental question (What if Susi had taken her shoes off, would the floor be clean or dirty?), then they would reason "if shoes are taken off, the floor is clean" and give the wrong answer (clean). In fact, of course, the floor will stay dirty as even if Susi hadn't have soiled the floor Max would still have done so.

Rafetseder et al. (2013) showed that children in the standard, undiscriminating, condition where there was only one protagonist, as in Harris et al.'s (1996) original study, did not encounter too many difficulties in answering correctly, but participants in the discriminating condition obtained different results. 5-to 6-years-olds answered correctly for only 18% of the situations, and even 7-to10-year-olds performed poorly with just 53% of correct answers. This study did not report adult-like counterfactual thinking until the age of 13. Children younger than 13 encounter difficulties with giving the correct answer to a counterfactual task that yielded a different response than the one obtained by a simple conditional reasoning.

These findings contradict other findings suggesting that 3-year-olds have little difficulty in reasoning counterfactually (e.g. Harris, 1997; German & Nichols, 2003). The point of interest of this study was whether children will encounter more difficulties with trials that could be solved only thorough counterfactual strategies as compared to trials that could be solved should other conditional reasoning strategy be employed. The results confirmed the authors' hypothesis; children performed significantly below chance on the trials where they could have reached the correct answer only by reasoning counterfactually. Overall, this

suggested that children's apparent success on counterfactual conditional tasks was the result of children being able to use basic conditional reasoning. In other words, evidence for counterfactual reasoning by 3- and 4-year-olds is based on false positives.

Rafetseder and her colleagues (2013) argued that previous evidence suggesting that preschoolers can reason counterfactually from the age of 4 (Beck et al., 2006 – standard counterfactuals; Guajardo et al., 2009 – both physical and mental tasks; Riggs et al., 1998) is not conclusive, because those types of counterfactual tasks can be answered with basic conditional reasoning. This is rather surprising, because even if we discount the evidence from counterfactual conditional tasks that may be answered using basic conditional reasoning, there are other tasks that seem to tap counterfactual reasoning that cannot be answered with basic conditional reasoning that are passed before adolescence (e.g.: O'Connor, McCormack, & Feeney; 2012 – regret trials; Beck et al., 2006 – open counterfactuals; Weisberg & Beck, 2010 – counterfactual emotions). For instance, in two experiments (O'Connor et al., 2012), 4- to 9-year-olds chose one of two boxes. Each box contained a prize; in the regret trials the lost prize was more valuable than the won one, whereas in the baseline trials both boxes contained exactly the same prize. 6-to 7-year-olds and 8-to 9-year-olds experienced regret in the counterfactual trials; moreover, participants in these age groups were able to explain why they felt sadder after finding out that the other box contained a more valuable prize. Children in this study reported feelings of regret by the age of 6. Children experiencing regret should also be able to reason counterfactually, as in order to understand, experience, and explain regret one compares the obtained outcome with a counterfactual one.

Why is it then, that Rafetseder et al. (2013) reported such a poor performance on a counterfactual task in children up to the age of 12? One possibility is that children might not have properly understood the task at hand. A few of the adolescents that answered incorrectly

to the discriminating version explained their understanding of the story: they thought that if the first character will not do the action, neither will the second one. Thus, there is a chance that children did not understand that if the first protagonist had not done something (e.g.: had not worn the dirty shoes) the second character would have still acted the same (e.g.: would have kept the dirty shoes on). This would mean that children were reaching an incorrect answer not through basic conditional reasoning, but because they were thinking of a different counterfactual to the one Rafetseder et al. had intended. Perhaps supporting children's counterfactual reasoning with additional wording will lead to a better understanding of the task and thus to better performance.

4.2.3. Aims of current study

Our study involved the reuse of Rafetseder et al.'s (2013) stories. In the undiscriminating version we used standard counterfactual stories. An example of such story involved Eddie who came from school, went into his room and decided to play the drums; because of the noise his baby sister, who was sleeping previously, woke up and started crying. In the discriminating story, Mum dropped a pot in the kitchen immediately after Eddie started playing his drums. In both versions children were asked the question "What if Eddie had not have played the drums, would the baby be awake or asleep?"According to Rafetseder and colleagues, the undiscriminating stories should be easier to answer through basic conditional reasoning, whereas discriminating stories might prove more difficult as children have to engage in counterfactual reasoning to answer to the task. While the undiscriminating story could have been solved through basic conditional reasoning (if Eddie does not make any noise, than the baby will keep sleeping), using the same strategy for the discriminating version would lead to the wrong answer. The right answer is "asleep" in the undiscriminating

condition, but "awake" in the discriminating condition, as Mum would have still dropped the pot. As well as the undiscriminating and discriminating versions, we introduced a new version of the discriminating story with the inclusion of the word *just* in the experimental question ("What if *just* Eddie had not made any noise, would the baby be asleep or awake?"). Our aim was to investigate whether the inclusion of the word *just* in the counterfactual question would help children to understand that the second character is still performing the action when the first character wouldn't perform the action anymore.

4.3. Methods

4.3.1. Participants

Fifty-three participants, 5-to 7-year-old children (with a mean age of 5.9 years, SD = 7.54) took part at this study. Children were recruited from the elementary school in the small mining town, Abrud and a primary school in the rural area, Roșia Montană (Alba County, Romania). Both institutions served a working-class population of Romania. The distribution across gender and ethnicity was at follows: 52.8% boys, and the majority of 88.7% Romanian and respectively 11.3% Romani. All participants spoke Romanian as their first language and were verbally articulate.

4.3.2. Materials

For this study, we developed four experimental stories starting from Rafetseder, et al.'s (2013) study: a dirty floor, sleeping, painting and getting wet story (See Appendix 3). These stories were translated from English to Romanian by one of the researchers and translated back from Romanian to English by an experiment-blinded translator. No major

differences were noted between the original and the translated from Romanian to English versions. For each of the four stories included in this study there were three versions: the undiscriminating version that Harris and colleagues (1996) used in their study, the discriminating version that Rafetseder et al. (2013) developed for their study, and the new "just" condition. For three of the stories we used 8-10 cm tall plastic dolls; the exception was the painting story where we used 4 cm tall dolls. We also used props such as plastic or wooden toy furniture items, toy cups and teapots, and a garden made of card, watercolours to simulate mud and three aluminum foil ponds.

4.3.3. Design

As in Rafetseder and colleagues' (2013) study, all participants received all the four stories in the order of (1) sleeping baby, (2) dirty shoes, (3) painting and (4) getting wet. Each participant answered 2 undiscriminating trials and also 2 discriminating or 2 just trials, i.e. the type of question asked in the discriminating stories was a between subject factor. For each story, participants answered a now control question (for the sleeping baby task: Is the baby asleep or awake/ awake or asleep now?) and a before control question (Was the baby asleep or awake/ awake or asleep before?). The order in which the participants received the three versions was fixed to counterbalance the conditions and stories: the first four participants always received the sleeping baby and the dirty shoes stories in the undiscriminating condition, while the next two stories were received either in the discriminating conditions (by Participant 1 and 3), or in the just condition (Participant 2 and 4). The next 4 participants always received the painting and getting wet stories in the undiscriminating condition, whereas two of the participants received the remaining stories in the discriminating condition (Participant 5 and 7), and two of the participants in the just condition (Participant 6 and 8).

The target adjectives were balanced so that half of the participants heard one order (e.g.: "would the baby be asleep or awake?") and half the opposite order (e.g.: "would the baby be awake or asleep?")

4.3.4. Procedure

The testing was conducted in a quiet area of the school and took no more than 15 minutes per individual. Each participant was told four stories that were acted out with dolls. After each story the children were asked the two control questions followed by the experimental question matching the condition. For example, in one of the stories a character, Eddie is at home and waits for his dinner to be cooked. Then Eddie starts playing the drums and wakes his baby sister up. In the undiscriminating version, this story ended here and children received the two control questions 'Is/ was the baby awake or asleep/ asleep or awake now/before?' followed by the experimental question: "What if Eddie had not made any noise, would the baby be awake or asleep?" (Romanian version: Dacă Eddie nu ar fi făcut zgomot, surioara lui ar dormi sau ar fi trează?)

In the discriminating version the story continues with Eddie's mum noisily dropping a teapot in the kitchen straight after the drums started being played. The questions that the participant heard were the same as in the standard condition.

The just condition was a variation of the discriminating condition; instead of receiving the standard experimental question, the participant was asked: "What if *just* Eddie had not made any noise, would the baby be awake or asleep?" (Romanian version: Dacă *numai* Eddie nu ar fi făcut zgomot, surioara lui ar dormi sau ar fi trează?)

All of the other stories were similar to this. In the dirty floor, a girl rushes inside after playing in her muddy garden without taking her shoes off; in discriminating and just versions the girl is followed right away by her sister who has muddy shoes also. In the painting story, a boy is drawing a tree on a blank piece of paper; in the discriminating and just stories right after the boy starts drawing, his friend draws as well on the same piece of paper. In the last set of stories Danny is waiting outside for his friend. Behind him, there is a big puddle and his friend cheekily plays a trick on him and jumps in the puddle splashing water on Danny; in the discriminating and just stories right after the first boy splashes Danny, a second friend jumps in the puddle and splashes Danny as well.

4.4. Results

4.4.1. Control questions

Five children were excluded from the sample as they gave fewer than six correct answers to the eight control questions. The age of these children ranged from 4 years and 8 months to 6 years and 5 months old. The other forty eight children gave quite accurate answers, all of them answering at least 6 out of eight questions right; and forty-four children gave at least 7 correct answers (91.6%). We therefore accepted that these 48 children had a good understanding of the stories.

4.4.2. Subjunctive counterfactual questions

We used two types of questions: the standard question for the undiscriminating stories and the discriminating stories, and the just questions for the just stories.

Children performed very well on the undiscriminating condition where there was only one person performing the action. Only one of the 48 children answered the standard questions wrongly. This finding supported Harris et al.'s (1996) reported results, as 96.2% of our participants gave the correct answers for the standard type of questions. Because only one participant gave one wrong answer to the standard questions in the undiscriminating condition, we treated this variable as if it were at the ceiling value of two when comparing it against the other two conditions.

Children in the undiscriminating condition might have used a conditional reasoning strategy to get to the right answer instead of reasoning counterfactually. It was essential to compare the undiscriminating conditions with the discriminating ones (both discriminating and just). First we compared children's performance on the discriminating trials to the undiscriminating trials. Because performance on the undiscriminating trials was close to ceiling we used one-sample t tests comparing to a target of 2. There was a difference between the versions (t (21) = -19.385, $p < .0001$) with the discriminating version being found more difficult by our group (M = .22) than the undiscriminating version. These results were in line with those by Rafetseder and colleagues. We then compared the undiscriminating trials with the just trials. The same pattern was observed (t (25) = -7.822, $p < .001$); the just version was answered with greater difficulty (M = .73) than the undiscriminating version.

The main question of this study was whether the inclusion of the word just in the counterfactual question would support children's understanding that the second character is still performing the action when the first character wouldn't perform the action anymore. We also decided to investigate whether any effect differed with age.

We split the data by age using a median split. This resulted in a younger group – younger than 5-years and-11-months-old (N = 22) and an older group – older than 5-years

and-11-months-old (N =26). A two way (2 x 2) ANOVA examining the effect of age (younger vs. older) and condition (discriminating vs. just) on answering counterfactuals was conducted. The means and standard deviation for answering counterfactual tasks as a function of age and condition are presented in Table 3.

Table 3. Means* (and standard deviations) for discriminating and just counterfactual trials

	Young	Old
Discriminating	.01	.31
	(.01)	(.47)
Just	.87	.50
	(.88)	(.70)
Total	.63	.38
	(.84)	(.57)

*The means presented in the table are out of a score of 2

The results of this two-way ANOVA indicated a main effect for condition, F (1, 44) = 6.44, $p < .015$, $\eta^2 = .128$, there being a difference in score between those who were in the discriminating group (M. = .22) and those who were in the just group (M. = .73). Being in the just group increased children's performance on counterfactuals compared to children in the discriminating condition.

There was no significant interaction effect between the effects of condition and age on answering counterfactuals (F (1, 44) = 2.69, $p < .10$, $\eta^2 = .058$); also, no statistically significant effect of age on counterfactuals was observed (F (1, 44) = .022, $p < .88$, $\eta^2 = .001$).

4.5. Discussion

Experiment 2 tested whether Rafetseder et al.'s claim that children cannot fully reason counterfactually until the age of 13 is valid. They claimed that children in the discriminating versions perform poorly because they do not master counterfactual reasoning, whereas children's good performance on undiscriminating trials is the result of false positives. We investigated whether children misunderstood the stories and generated unexpected counterfactuals. We tested whether additional wording would help 5-to 7-year-olds to better understand a counterfactual task in which two characters were performing the same action one right after the other. We included the word *just* in one of our trials and checked whether children will improve their performance on Rafetseder et al.'s discriminating trials.

Our results suggested that children performed much better on undiscriminating trials than on either type of discriminating trials. Children in both age groups performed very well on the undiscriminating trials, almost reaching ceiling. These findings are in concordance with those of Harris et al. (1996) who suggested that children younger than those in our samples solved counterfactual tasks with ease. In Harris and colleagues' study, 3-to 4-year-olds answered 69%, and 4-to 5-year-olds answered 85% of the trials right; in our study 5-to-7-year-olds answered 96% of the trials correctly. Our finding of improved performance by the older children is in line with Rafetseder et al. (2013) who reported a similar result of 93% correct answers given by 5- and 6-year-olds for undiscriminating tasks. Rafetseder and colleagues claimed that children in the undiscriminating task performed much better than children in the discriminating trials because they made use of their general knowledge. However, these authors failed to consider the additional reasoning demands children had to answer in the discriminating tasks compared to undiscriminating tasks (Beck and Riggs,

2014). The first type of tasks has a greater informational load, and children are required to counterfactually consider more alternatives than in the undiscriminating version.

Our participants found both discriminating and just trials more difficult than the undiscriminating version. Only 25% of the children (N = 12) solved one of the two trials correctly, and only 12.5% (N = 6) solved both trials correctly. These results show a similar performance to the one reported by Rafetseder and colleagues (2013). Rafetseder et al. reported that 5 and 6-year-olds answered correctly in only 18% of the trials; moreover, no children in this age group answered correctly to both discriminating trials. This would support Rafetseder et al.'s idea that the undiscriminating trials are being solved using a different strategy to the discriminating trials; while children had no difficulties in solving the undiscriminating trials, their performance dramatically dropped when they solved discriminating trials. It is essential though to acknowledge the differences that we found between the discriminating and just type of trials. There was a notable difference on children's performance on the discriminating and just conditions. Children in the just group performed better than those in the discriminating condition. Whereas only 11% of the discriminating trials were answered correctly, 36.5% of the just trials were answered right.

Why did children in our group find the just version easier than the discriminating version? The discriminating and just versions had the same scenario complexity. Both scenarios required children to bear in mind not just one single set of sequences (as the undiscriminating version), but two sets of sequences (i.e.: 1.Eddie came home while his baby sister was asleep. → Eddie decided to play the drums. → Eddie made noise. And 2. Mum was in the kitchen while the baby was asleep. → Mum dropped a tea pot on the floor. → Mum made noise).

Children in our just condition showed an improvement in solving the same counterfactual scenario as children in our discriminating condition. This suggests that children do engage in some form of counterfactual reasoning at the age of 5. Although Rafetseder et al. (2013) claimed that children cannot engage in genuine counterfactual thinking before the age of 6, previous research suggests that some development in counterfactual thinking occurs before and during the 4th year of age. By the age of 4, children have the ability to reason with false information, and to ignore the truth (Beck, Riggs, & Burns, 2011; Riggs et al., 1998; Guajardo & Turley-Ames, 2004). This could explain why children in our sample performed so well in solving the undiscriminating counterfactual trials; which is why they had little difficulty in inhibiting reality and working with false content. Nevertheless, further developments occur in children's counterfactual reasoning ability after the age of 5. For instance, thinking about dual or multiple possibilities is considered to be one of adult-like counterfactual thinking trademarks (Thompson & Byrne, 2002; Byrne, 2005). Thompson & Byrne (2002) argued that in interpreting subjunctive conditionals, reasoners have to represent both the false and the true antecedents, as the false and the true consequents and to hold them in mind. If children do not start to represent the real and counterfactual world after the age of 4, this could explain why they find the discriminating and just trials harder than the undiscriminating trials.

Beck et al. (2006) compared 3-to 6- year-olds responses to standard and open counterfactuals. Children saw an undetermined possibilities trial, in which a toy mouse was sliding on a slide that had two ends. Before starting the game, children had to place cotton mats at the end of the slide, so that the mouse could land safely. At the end of this game children were asked the standard counterfactual question (What if he had gone the other way, where would the mouse be?) or the open counterfactuals (Could anything else have

happened?). Results suggested that children answered standard questions much easier than open counterfactuals; moreover, children usually placed a single mat, guessing the end the mouse will exit to, instead of two mats – which would have ensured a safe landing for the mouse. Beck et al. argued that while standard counterfactuals do not require thinking of dual possibilities, the undetermined trials and open counterfactuals required thinking about a point in time when both events could have occurred, but when only one led to the real outcome. Undiscriminating trials, as opposed to discriminating trials, might then be solved more easily than discriminating ones not only because children use basic conditional reasoning, as Rafetseder and colleagues suggested (2010; 2013), but also because they do not require children to acknowledge dual possibilities.

Children's difficulty with discriminating counterfactual tasks could be accounted for by appealing to working memory demands. Beck et al. (2011) argue that it might be possible that the role of working memory became essential in counterfactual thinking, only at the point when children can hold multiple worlds in mind (see above Beck et al., 2006 - open counterfactual task). There are studies that report that higher scores on working memory tasks correlate with better performance on counterfactuals (Drayton et al., 2011; Guajardo et al., 2009), especially on the antecedent counterfactual tasks. Working memory might play an important role in generating possible worlds as it helps holding in mind different aspects of different worlds. The inclusion of the word *just* improved children's performance to the counterfactual task. The additional wording might have supported children's working memory. The discriminating stories contain extra information (e.g. not only Susi, but also Max had dirty shoes on and have walked on the clean floor) which could be effortful and, thus, might place more demands on children's working memory. Additional wording seem to help children remember which information is relevant to solve the discriminating

counterfactual task. Evidence from Carroll et al.'s (2007) study suggests that additional wording ("Point to a box for me to open *so that I don't get the sticker*") helps 3-to 4-year-olds to perform better on the Windows task. The wording manipulation in Carroll and colleagues' study might have supported children's performance by reminding them their task of deceiving the experimenter (and therefore minimizing the working memory demands). Future studies should include measures of executive concepts as well, to better understand the relationship between discriminating stories and executive demands.

Beside the working memory account, we also consider that Rafetseder et al.'s (2013) explanation is plausible for the difference between undiscriminating and discriminating trials. We argue that while this account could explain the difference in performance between Harris et al.'s undiscriminating (1996) trials and Rafetseder et al.'s discriminating trials, it could not account for the difference between children's performance on just and discriminating trials. Our results indicated that although our just version is more difficult than the undiscriminating version, it is easier than the discriminating version. This suggests that children can engage in counterfactual thinking when solving a discriminating version, if this task is clarified. It might be that children do not answer correctly the discriminating trials because they are misleading. In other words, children might generate a different counterfactual alternative than the one we expect. We consider the possibility that children could engage in generating a counterfactual world where both characters are not performing the action anymore. For example, Rafetseder et al. (2013) reported that 3 of the 5 13-to 15-year-olds that considered that Eddie's sister would not had woken up if (only) Eddie had not made any noise, justified their answers by saying that if Eddie had not made any noise, the second character would not had made any noise either. There is a chance that children did not understand that there is no link between the way that the two characters behave. It is possible that children in the discriminating trials

gave incorrect counterfactual answers not because of engaging in basic conditional reasoning, but because they were thinking of a different counterfactual to the one Rafetseder et al. had intended. The word just might have helped them improve their performance by clarifying the task.

In conclusion, we replicated both Harris et al.'s (standard trials) and Rafetseder et al.'s (discriminating trials) findings. Our new just trials suggest that one reason why children fail to answer correctly in the undiscriminating version is because they fail to keep the task goal in mind. Also, children might have difficulties in representing multiple possibilities and holding them in mind. Perhaps, the discriminating type of task place extra demands on children's working memory. However, as the just version remained more difficult than the standard version, it likely that children's counterfactual reasoning undergoes further development. Future work should investigate at what age children consistently answer the just question correctly.

5. GENERAL DISCUSSION

5.1. Overview

The research in this dissertation aimed to shed light on the way children's counterfactual reasoning could be supported with alternative ways of response or additional wording. This final chapter seeks to briefly highlight the main points or findings of the previous chapters and the way they could influence future research.

5.2. Summary

We have suggested, in our first chapters, that although counterfactual conditionals are commonly experienced by adults (Roese, 1999; Roese & Olson, 1995; McCloy & Byrne, 2002), young children encounter difficulties in understanding and mastering counterfactual statements (Beck et al., 2011; Beck et al., 2006; Rafetseder et al., 2013; Rafetseder et al., 2010; Ferrell et al., 2009). As counterfactual reasoning is linked to understanding causality (Beck et al., 2006), decision making (Roese, 1994), and facilitating behavioural strategies (Smallman & Roese, 2009; Epstude & Roese, 2008) among others, it is crucial that we understand the way children develop this type of thinking. The counterfactual world is created with the purpose of gaining an insight into the real world, making inferences about the real world (Harris et al., 1996; Roese, 1997; Beck et al., 2006), learning from mistakes (Roese, 1997, 1999) and reappraising past situations (Amsel & Smalley, 2000; Riggs et al., 1998). The next sections represent short summaries of our experimental methods and findings.

5.2.1. An asymmetrical relationship between counterfactual and real worlds

Our first two studies sought to investigate whether children's counterfactual reasoning performance could be facilitated by novel modes of response and different question types. In two studies, we demonstrated these two different aspects of a counterfactual task (i.e. question type and response mode). British and Romanian children heard four counterfactual stories both in their standard form and in a new version. The standard form presented children with a sequence of events and their outcome, and children had to judge how the world would be if the main event did not happen. Our new version on the other hand presented the same sequence but as a series of counterfactual alternatives; children heard how the world would had been if an event had not had occurred and had to infer how the world actually looks like. Also, children's way of responding differed from trial to trial; such that, they answered two trials pointing with their finger, and two trials pointing with an arrow. Our findings from this study suggested that children in both the British and the Romanian group did not benefit from the arrow manipulation; their responses to the two types of trials were not above chance. This suggests that the inhibitory role of the arrow delay is more fragile than previously showed. On the other hand, our findings showed that children in the Romanian group found inferring reality from a counterfactual sequence easier than the reverse. British children showed the same pattern, but results in this sample did not reach significance. These findings suggest that the relationship between counterfactual and real worlds is asymmetrical.

5.2.2. Complex scenarios or misleading scenarios?

Our second investigation was conducted with a Romanian sample and it was based on Rafetseder at al.'s (2013) claim that very young children that resolve counterfactual tasks correctly are false positives. Rafetseder and her colleagues argued that children, solving a

sequence involving a mishap happening to a character, are not using counterfactual reasoning as their solving strategy but their background knowledge, which was referred to as basic conditional reasoning. Rafetseder et al. tested whether children respond as well to more complex scenarios that involved two characters doing the same action one right after the other. When children were asked how things would have been had the first character failed to do that action, their performance on the task decreased dramatically. These results supported the authors' claim that children cannot solve counterfactual tasks until after the age of 12. This evidence created an empirical problem, for there are many results supporting the account that children develop their ability of reasoning counterfactually after the age of 4 (e.g. Riggs et al., 1998; Beck et al., 2006; Beck et al., 2011; Ferrel et al., 2009).

We suggested that the very poor performance on Rafetseder et al.'s (2013) study could be due to the task being misleading or to additional demands on children's working memory. We administered three versions of the counterfactual task: the undiscriminating one that presented just one character, the discriminating one based on Rafetseder et al. that presented two characters performing successively the same action, and our new version. Our new version was based on Rafetseder et al.'s version, but we included the word just in the counterfactual question. Our results showed that Rafetseder et al.'s version proved difficult for 5- to 6-year-old children; our results on this task were very similar to the ones obtained by Rafetseder and her colleagues. This supported their claim that children cannot solve counterfactual trials above chance. Nevertheless, when we analyzed our new version, a significant improvement in children's performance could be noticed. The addition of the word just supported children's counterfactual reasoning. We proposed two possible explanations for this finding. (1) The inclusion of the word just in the final question reduces the working memory demands by reminding participants that the task refers to two characters. And (2), the

inclusion of the word just brought further clarification of the task, thus children understood that although the first character would stop acting, the second character would still be performing that behaviour.

5.3. Counterfactual reasoning across cultures

This section tries to put together evidence showing whether our results could be accounted by cultural differences. In our studies we used one English sample and two Romanian samples. Can our results be generalized to other samples, or are they speaking solely about our Romanian samples?

Accounts of the relation between linguistic ability and thought divide between claims that either there is no connection between the two variables or that the grammatical structure of a language influences the way people think (Bloom, P. & Keil, 2001). Bloom and Keil (2001) argue that while language might be essential for the thinking process as a mean of communication, probably it does not influence thinking in any other way. However, certain grammatical structures might be necessary for mastering certain cognitive processes; for example, children's false belief was found to be related to children's understanding and full command of specific grammatical structures (i.e. relative clause sentences)(Smith, Apperly, & White, 2003).

One of the earliest accounts, the Sapir-Worf hypothesis states that structural differences between languages are doubled by cognitive differences in the native speakers of those languages. Early evidence supporting the Sapir-Worf hypothesis comes from A. H. Bloom (1981) who noticed that while English has a specific grammar structure to introduce counterfactuals, the Chinese grammar has no such mood; their counterfactuals are introduced

through an "if-then" construction which does not necessarily identify subjunctives. He argued that abstract thinking might be influenced by structural language constructions. To test this idea, he conducted a series of studies of counterfactual generation with adults from the U.S. (the English version), Hong-Kong, and Taiwan (the Chinese version). All groups heard the same counterfactual story in either English or Chinese. The results of this study showed that while 98% of the American participants gave counterfactual interpretation to that story, only 7% of the participants from Hong-Kong and Taiwan did so. A.H. Bloom (1981) argued then that these results showed the role of subjunctive in English speakers' counterfactual thinking. He further added to this conclusion through another study showing that (1) Chinese speakers improved their performance from 7% to 50% when the story they heard contained additional linguistic cues signaling the counterfactual mode, and (2) bilingual Taiwanese participants increased their performance from 7% (in the Chinese version) to 86% when they heard the story in English. Overall, these two studies suggested that counterfactuals are supported by linguistic constructions.

Au (1983) argued that while A.H. Bloom's (1981) findings are revealing an important relationship between the grammar of a language and abstract thinking, they are inconclusive, as the effects observed could be due to participants' previous exposure to the same task, and not to an actual improvement. She conducted a series of 5 studies; two of her studies suggested the bilingual adults had no difficulty in understanding counterfactual stories when these were written in Chinese or English. The third study revealed that bilingual adolescents aged 15 to 18, understood counterfactual stories whether these were presented in English or Chinese. The fourth study conducted by Au, suggested that American high-school students, aged 15-18, gave significantly less correct counterfactual answers to the English version of the story, than participants from Hong-Kong to the Chinese version – this result is the

opposite of earlier findings of A.H. Bloom. The fifth study showed that Chinese-speaking 9-to 15-year-olds, who were unlikely to have mastered the English subjunctive, were able to give counterfactual answers to the story. This set of evidence does not support the hypothesis that counterfactual thinking must be supported by specific grammar structures, such as subjunctive. Chinese participants had no difficulty solving counterfactual stories, as long as the story they heard was formulated idiomatically. Taken together, these two studies showed that A.H. Bloom's findings were due to experimental design problems, and when these were fixed, the difference between Chinese and English counterfactuals faded away. Therefore, people from these two cultures share a common ground in understanding counterfactuals and making inferences from a counterfactual story.

Adding to this, evidence from counterfactual emotions also showed that people from different cultures tend to have more inaction long-term regrets (Gilovich & Medvec, 1995; Gilovich, Wang, Regan, & Nishina, 2003; Komiya, Miyamoto, Watabe, & Kusumi, 2011). Gilovich and Medvec (1995) claimed that on the long run, Americans tend to regret more what they did not do than what they did. Davidson & Feeney (2008) further suggested that British participants in their 40s and 60s tend to regret their inactions more than their actions; also the authors added that these regrets were rather general, and not specific. Gilovich et al. (2003) investigated whether experiencing regret might be influenced by cultural factors and how people experience regret in China, Japan, and Russia - that are all collectivist cultures. Participants in the three studies were prompted to look back and identify their main regret. Consistent with previous findings from American or British samples, Chinese, Japanese and Russian participants reported regretting more inactions than actions when looking back on their past. Nevertheless, Komiya et al. (2011) found that while both American and Japanese students tended to regret more inactions than actions in a self-focused situation, Japanese

participants reported more action than inaction regrets in interpersonal situations, and American participants tended to feel as much regret over inactions as over actions in interpersonal situations. Overall, these studies suggest that despite certain cultural differences, participants from both individualist and collectivist cultures share commonalities in the way they consider what they regret most, all participants reporting greater levels of regret over time for something they fail to do than for something they did.

The commonality shared between different countries and cultures was supported by another study in the counterfactual emotions field by Van de Ven et al. (2009). The authors argue that counterfactual thinking is relevant to envy "Because envy is inherently a comparison-based emotion (one compares one's own situation to that of another)" (p.427). Furthermore, counterfactuals distinguish two types of envy: benign envy "It could have been me" from malicious envy "It should have been me." In this study, Van de Ven and his colleagues tried to establish the differences between benign and malicious envy in a group of Dutch participants. It was possible to do this because Dutch is a language that holds different terms for benign and malicious envy. The study showed that Dutch participants did differentiate between the two types of envy which were associated with opposite attributes (e.g. malicious envy is associated with negative thoughts, while benign envy is associated with positive thoughts). A further study suggested that although Americans have no differentiating linguistic label for malicious and benign envy, they can, however, differentiate between the two. Both American and Dutch participants identified similar characteristics for malicious and benign envy, which indicates that malicious and benign envy might be expressed and defined in the same way across cultures.

There are only few studies on the development of counterfactual reasoning that were conducted on other cultures than American, British, or the German speakers of Perner's work.

One example is that of German and Nichols (2003), who assessed whether children encounter difficulties when they have to make counterfactual inferences from a long causal chain compared to a short causal chain. Participants in this study were Greek 3- and 4-year-olds that had Greek as their first language. They heard a story encompassing three events that lead to a result (e.g. A Mrs. Rosy was happy after planting her flowers. What happened was that (1) she called her husband (2) who came out of the house and also let the dog escape, and (3) the dog squashed Mrs. Rosy's flowers. As a consequence the flowers were squashed and Mrs. Rosy ended up sad). Children had to infer whether the result would have occurred had one of the three events not happened. The results of this experiment indicated that children's ability to draw counterfactual inferences depended on the length of the causal chain and, thus, on the degree of complexity of the inference task. Thus, the main findings revealed that Greek children found the short counterfactual chains (referring to event 3) much easier than either the medium (event 2) or the long (event 1) ones. From this study we could draw the conclusion that children find easier to infer a counterfactual conclusion from a short causal chain than a more complex causal chain.

Nevertheless, Beck et al. (2010) failed to replicate German and Nichols (2003) findings with a group of British, English-speaking, 3- and 4-year-olds. Children in their studies heard counterfactual stories based on German and Nichols' stories that involved either an emotional or a location change. The results of two of the studies showed that children's performance on counterfactual tasks is not influenced by the length of the inference, while three other studies showed that children with lower language ability performed more poorly on the short causal chains than on the long causal chains. Also, Beck et al. did not find any evidence supporting the claim that children as young as 3 could engage in counterfactual thinking. Could this difference in performance on German and Nichols (2003) and Beck et al.

(2010) be the result of cultural differences? There is a lack of evidence on the cross-cultural development of counterfactuals, thus we cannot determine with certainty if cultural factors account for any differences observed in these two studies. Beck and her colleagues' result, that children's performance depended on their linguistic abilities, suggests that counterfactual tasks make additional linguistic demands. It is possible that Greek and British children experience a different linguistic development which in turn would contribute in a different manner to their ability to create complex models about given events, and also to make inferences based on these models.

Considering the evidence presented above, we question whether the results obtained in our research from Romanian samples could be generalized to other cultures. Our studies used three samples of children of which one was formed of British preschoolers, and the other two of Romanian preschoolers. In our first investigation, we used an English and a Romanian sample. We had no statistically significant results for the English sample, but we did find that children in our Romanian sample answered better on counterfactual tasks when they heard a counterfactual statement and had to infer what the real event was than when they heard what happened and had to generate a counterfactual alternatives. An alternative is that the difference between the two samples could have occurred, not because of cultural differences, but because our English sample was smaller and also formed of younger children than our Romanian sample. Moreover, a pilot study conducted by Beck & Sunda (2012) also found that 4-to 5-year-old British children found it easier to infer reality in a counterfactual task, than to generate counterfactual alternatives. To our knowledge, there are no other studies that have manipulated this aspect of counterfactuals (i.e.: hearing counterfactuals and inferring reality, or hearing the reverse), thus, we suggest that children from cultures other than the British and Romanian ones might also find inferring reality from a given counterfactual easier

than generating a counterfactual alternative to a real event. It would be useful to replicate findings with samples who speak diverse languages.

The evidence presented, although scarce, supports the idea that counterfactuals share a common ground across cultures. To add to this, in Experiment 2, our Romanian sample obtained similar results with Rafetseder and her colleagues's (2013) German-speaking sample on the discriminating trials. Overall, this suggests that our results are more than a mere reflection of the Romanian culture on our set of tasks.

5.4. Future research

The development of counterfactual thinking is an exciting research area. First, knowing the cognitive processes that underpin the acquisition and use of counterfactuals by both adults and children is crucial in building a valid account on how counterfactuals could influence our daily decisions, moral and causal judgments, and attributions (e.g. Beck & Riggs, 2014; Epstude & Roese, 2008). As such there are many aspects of this field that need further investigation. In this section we will summarize a few possible suggestions.

The primary aim of our first experiment was to investigate whether children could improve their performance on two different counterfactual tasks when we manipulated certain aspects of those tasks, which were novel ways of response or new question types. Our first investigation did not support the alternative response mode manipulation although previous research did (Beck et al., 2011; Carroll et al., 2007; Carlson et al., 1998), but it suggested that manipulating the question type supported and facilitated children's counterfactual reasoning. Although the arrow delay facilitated children's performance on deceiving tasks (Carlson et al., 1998), counterfactual tasks (Beck et al., 2011), and the Window task (Carroll et al., 2007;

Carroll et al., 2012), it seems to have no effect on false belief tasks and an inhibitory control tasks (Carroll et al., 2012). In addition to this, we did not find any support for the claim that the arrow manipulation could benefit our 3- to 5-year-olds. Our counterfactual tasks differed from those used by Beck et al. (2011), therefore we suggest that future research should test the arrow delay manipulation, together with other type of delay manipulations (see Beck et al., 2011 – the slide delay), on a wider range of counterfactual tasks. Specifically, one of our suggestions is to test the arrow manipulation on RtC and CtR tasks that imply not only state changes (as our current study did), but also tasks that refer to location or emotional changes.

Our question type manipulation yielded significant results, with 3-to 5-year-olds answering more counterfactuals correctly when they heard the counterfactual alternatives and inferred reality, than in the standard condition. As we argued in the previous section, it is very unlikely that these results arose only as a result of cultural factors. We also suggested that these differences between the two types of trials appear as inferring reality from a counterfactual is less demanding in terms of inhibitory control. Participants might find it less challenging to infer an actual outcome from an already given counterfactual alternative, than to build counterfactual alternatives that are contradicting what they know as being real.

Recent evidence suggests that children's ability to reason counterfactually is underpinned by improvements in inhibitory control (Beck et al., 2009). Three different counterfactual tasks were considered by Beck et al. (2009): syllogisms, causal chains, and location change sequences – the causal chain and the location change task were predicted by measures of inhibitory control and by linguistic ability. To our knowledge, our counterfactual to reality task has not been investigated before. Future research is needed in order to investigate whether this type of task is underpinned by developments in inhibitory control.

Also, it would be useful to know if children in other cultures will find this task easier than standard counterfactual tasks.

As we pointed out above, not all counterfactual tasks were predicted by inhibitory control in Beck et al. (2009), specifically children's syllogisms performance was not related. Inhibitory control helps children master tasks that require ignoring reality such as causal chains. Is it likely that the task we used in our second investigation makes substantial executive control demands? In our third study we had three different conditions: an undiscriminating, a discriminating, and a just condition. Children had no problems in solving the undiscriminating version of our task, their performance almost reaching ceiling. This result could be explained in two ways: (1) As Rafetseder et al. suggested children did not engage in counterfactual reasoning, but in basic conditional reasoning; this means they used their knowledge that people wake up if there is a lot of noise and by using an "if…then" strategy they solved the given tasks correctly. Or (2) children's counterfactual thinking was supported by developments of inhibitory control; therefore, children were already able to ignore reality and give the right answer for this type of task.

The difficulty seen on both the discriminating and just versions compared to the undiscriminating version is difficult to explain through further inhibitory control developments. Rafetseder et al. (2013; see also Rafetseder et al., 2010) argued that this result suggest that children lack the ability to think counterfactually. Rafetseder and her colleagues claimed that counterfactuals are a late development, and that 3-to 4-year-olds cannot think counterfactually; in fact, they claim that evidence showing children of 3, or of 4 solving counterfactual tasks (Guajardo & Turley-Ames, 2004; Harris et al., 1996; Riggs et al., 1998) is formed of false positives. On the other hand, there is evidence showing that children can actually engage in some counterfactual reasoning at the age of 4 and that this ability continues

developing (Beck et al., 2011; Beck et al., 2010; Beck et al., 2006; Guttentag & Ferrel, 2004). We suggest that children's ability to solve more complex tasks such as the discriminating task could be supported by other developments on executive control. What we suggest is that children can engage in some counterfactual tasks at the age of 4, but other types of counterfactuals (e.g. open-counterfactuals) develop after the 4th year of age.

It has been suggested that executive control undergoes extended development over the years (Dumonteil, in press). Recent evidence, especially results from studies conducted on counterfactual emotions (Guttentag & Ferrell, 2004; Ferrell et al., 2009) and open counterfactuals (Beck et al., 2006) indicated that children younger than 7 do not fully understand multiple possibilities. Byrne (2005) argues that holding multiple possibilities in mind is one of the defining features of counterfactuals; holding possibilities in mind might be influenced by working memory limitations and, thus, prove challenging. Children's understanding of multiple possibilities might be underpinned by developments in working memory occurring during middle childhood. In support of this view, recent fMRI data indicates that counterfactual thinking and episodic memory share a common brain network (Van Hoeck et al., 2013): areas vital for memory activation are also involved in counterfactual activation. Thus, we suggest that the improvement that children in our sample showed from the discriminating condition to the just condition is due to the word 'just' that diminished working memory demands by reminding participants the complex sequence (see similar results in Carroll et al., 2007). This account has to be further tested: we need to replicate the effect of including the word just in discriminating trials, but also the role of working memory in understanding possible alternatives. The evidence regarding the way working memory could support counterfactual generation is not yet compelling. Including a battery of tests measuring working memory together with open counterfactual, syllogistic, counterfactual

emotions and other type of complex counterfactual trials (such as discriminating trials) could only shed some light over counterfactuals development.

We suggest that complex counterfactual trials might be underpinned by multiple developments. For example, generating alternative worlds is supported by executive processes such as working memory (Guajardo et al., 2009), but also conceptual changes. An interesting account for the late development of counterfactuals came from McCormack & Hoerl (2008). McCormack and Hoerl suggested that counterfactual thinking is influenced by children's understanding of time. Their findings indicated that at the age of 5 children demonstrate understanding that different events fall into different time slots. We acknowledge that understanding different concepts such as time might prove essential in solving our discriminating tasks (e.g. understanding that first character's action belongs to a different time slot than second character's action). There is little developmental research on understanding counterfactuals as possibilities (Beck et al., 2006; Beck & Crilly, 2009), and on related conceptual changes. We suggest that future developmental research should focus on these less known aspects of counterfactuals. Perhaps, understanding such aspects could underpin our understanding of how and when children engage in spontaneous counterfactual thinking.

5.5. Final conclusion

This dissertation contains two investigations regarding the developmental trajectory of counterfactuals. In our first investigation, 4-to 5-year olds demonstrated that the link between the real and the counterfactual world is asymmetrical: inferring reality from counterfactual alternatives is easier than the reverse. Children from both age groups (3-to-4 and 4-to-5) did not benefit from an arrow delay manipulation; this manipulation was hypothesized to support

their counterfactual response by inhibiting impulsive answers. Our findings regarding the response mode, did not match previous evidence, and suggested a fragile influence of inhibitory response mode on counterfactual responses. To our knowledge there was no published study on counterfactual-to-reality tasks. Thus, this research could be a step forward in better understanding counterfactuals.

Our second investigation revealed that discriminating trials prove difficult even for children older than 5. Children's counterfactual responses to this sort of task were supported through additional wording. The inclusion of the word just in discriminating trials significantly improved children's performance. We suggest the additional word supported counterfactual reasoning by clarifying the task at hand, and by reducing working memory demands. Both of these accounts need further investigation.

These studies suggested that counterfactual trials are not trivially easy for children. More attention should focus on the executive aspects of counterfactual thinking that undergo an extended development during mid-childhood and that could explain later developments in the domain of counterfactuals. Counterfactual thinking is cognitively demanding and could be one of the components that make humans unique.

References

Amsel, E. & Smalley, J.D. (2000). Beyond really and truly: Children's counterfactual thinking about pretend and possible worlds. In P. Mitchell and K. Riggs (Eds.). *Children's Reasoning and the Mind* (pp. 121–147). Hove, England: Psychology Press.

Amsel, E., Trifoni, G., & Campbell, R. (2005). Reasoning about make-believe and hypothetical suppositions: Towards a theory of belief-contravening reasoning. *Cognitive Development, 20*, 545–575. doi:10.1016/j.cogdev.2005.08.002

Au, T.K.F. (1983). Chinese and English counterfactuals: The Sapir-Worf hypothesis revisited. *Cognition, 15*, 155-187.

Beck, S.R. & Riggs, K.J. (2014). Developing Thoughts About What Might Have Been. *Child Development Perspectives, 8*, 175-179. DOI: 10.1111/cdep.12082

Beck, S.R., Weisberg, D.P., Burns, P., & Riggs, K.J. (2014). Conditional Reasoning and Emotional Experience: A Review of the Development of Counterfactual Thinking. *Studia Logica, 102*, 673-689. DOI: 10.1007/s11225-013-9508-1

Beck, S.R. & Sunda, S. (2012). [An investigation on children's performance on counterfactual-to-reality and reality-to-counterfactual tasks]. Unpublished raw data.

Beck, S.R., Carroll, D.J., Brunsdon, V.E.A. ,& Gryg, C.K. (2011). Supporting children's counterfactual thinking with alternative modes of responding. *Journal of Experimental Child Psychology, 108*,190–202. doi:10.1016/j.jecp.2010.07.009.

Beck, S. R., & Guthrie, C. (2011). Almost thinking counterfactually: Children's understanding of close counterfactuals. *Child Development, 82,* 1189–1198. doi:10.1111/j.1467-8624.2011.01590.x

Beck, S.R., Riggs, K.J., & Burns, P. (2011). Multiple Developments in Counterfactual Thinking. In C. Hoerl, T. McCormack, & S.R. Beck (Eds.). *Understanding Counterfactuals, Understanding Causation* (pp 110-122.) Oxford: Oxford University Press. doi:10.1093/acprof:oso/9780199590698.003.0006

Beck, S.R., Riggs, K.J., & Gorniak, S.L. (2010). The effect of causal chain length on counterfactual conditional reasoning. *British Journal of Developmental Psychology, 28*, 505-521. doi: 10.1348/026151009X450836

Beck, S.R. & Crilly, M. (2009). Is understanding regret dependent on developments in counterfactual thinking? *British Journal of Developmental Psychology, 27*, 505–510. DOI:10.1348/026151008X401697

Beck, S. R., Riggs, K. J., & Gorniak, S. L. (2009). Relating developments in children's counterfactual thinking and executive functions. *Thinking and Reasoning, 15,* 337–354. doi:10.1080/13546780903135904

Beck, S.R., Robinson, E.J., Carroll, D.J., & Apperly, I.A. (2006). Children's thinking about counterfactuals and future hypotheticals as possibilities. *Child Development, 77,* 413-426. doi:10.1111/j.1467-8264.2006.00879.x

Bloom, A.H. (1981). *The Linguistic Shaping of Thought: A Study in the Impact of Language on Thinking in China and the West.* Hillsdale: Erlbaum Associates.

Bloom, P. & Keil, F.C. (2001). Thinking Through Language. *Mind and Language, 16*, 351-367.

Boninger, D.S., Gleicher, F., & Strathman, A. (1994). Counterfactual Thinking: From What Might Have Been to What May Be. *Journal of Personality and Social Psychology, 67*, 297-307.

Burns, P., Riggs, K.J., & Beck, S.R. (2012).Executive control and the experience of regret. *Journal of Experimental Child Psychology, 111,* 501–515. doi:10.1016/j.jecp.2011.10.003.

Byrne, R. M. J. (2005).*The rational imagination: How people create alternatives to reality.* Cambridge, MA: MIT Press.

Byrne, R.M.J. (2002). Mental models and counterfactual thoughts about what might have been. *Trends in Cognitive Sciences, 6*, 426-431.

Byrne, R.M.J. & McEleny, A. (2000). Counterfactual Thinking About Actions and Failures to Act. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*, 1318-1331. DOI: 10.1037//0278-7393.26.5.1318

Camille, N., Coricelli, G., Sallet, J., Pradat-Diehl, P., Duhamel, J.-R., & Sirigu, A. (2004). The Involvement of Orbitofrontal Cortex in the Experience of Regret. *Science, 304*, 1167-1170. DOI: 10.1126/science.1094550

Canessa, N., Motterlini, M., Di Dio, C., Perani, D., Scifo, P., Cappa, S.F., & Rizzolatti, G. (2009). Understanding Others' Regret: AfMRI Study. *PLoS ONE, 4*, 1-10. doi:10.1371/journal.pone.0007402

Carlson, S.M., Moses, L.J., & Hix, H. R. (1998). The role of inhibitory processes in young children's difficulties with deception and false belief. *Child Development, 69*, 672–691.

Carroll, D.J., Riggs, K.J., Apperly, I.A., Graham, K., & Geoghegan, C. (2012). How do alternative ways of responding influence 3- and 4-year-olds' performance on tests of executive function and theory of mind? *Journal of Experimental Child Psychology, 112*, 312-325. DOI: 10.1016/j.jecp.2012.03.001

Carroll, D.J., Apperly, I.A., & Riggs, K.J. (2007). The executive demands of strategic reasoning are modified by the way in which children are prompted to think about the task: evidence from 3- to 4-year-olds. *Cognitive Development, 22,* 142–148.

Davidson, I.M. & Feeney, A. (2008). Regret as autobiographical memory. *Cognitive Psychology, 57*, 385-403. doi:10.1016/j.cogpsych.2008.03.001

Diamond, A., Kirkham, N., & Amso, D. (2002). Conditions under which young children can hold two rules in mind and inhibit a prepotent response. *Developmental Psychology, 38*, 352–362.

Drayton, S., Turley-Ames, K.J., & Guajardo, N.R. (2011). Counterfactual thinking and false belief: The role of executive function. *Journal of Experimental Child Psychology, 108*, 532-548. doi:10.1016/j.jecp.2010.09.007

Dumontheil I., Burgess, P.W., & Blakemore, S.J. (2008). Development of rostral prefrontal cortex and cognitive and behavioural disorders. *Developmental Medicine and Child Neurology, 50,* 168-181.

Dumontheil, I., (in press). Development of abstract thinking during childhood and adolescence: The role of rostrolateral prefrontal cortex. *Developmental Cognitive Neuroscience.* http://dx.doi.org/10.1016/j.dcn.2014.07.009

Epstude, K., & Roese, N. J. (2008). The functional theory of counterfactual thinking. *Personality and Social Psychology Review, 12,* 168–192. doi:10.1177/1088868308316091

Feldman, J., Miyamoto, J., & Loftus, E.F. (1999). Are Actions Regretted More Than Inactions? *Organizational Behavior and Human Decision Processes, 78*, 232-255. DOI: 10.1006/obhd.1999.2833

Ferrell, J.M., Guttentag, R.E., & Gredlein, J.M. (2009). Children's understanding of counterfactual emotions: Age differences, individual differences, and the effects of counterfactual-information salience. *British Journal of Developmental Psychology, 27*, 569–585. DOI:10.1348/026151008X337743

Fincher, D. (Director) (2008). *The Curious Case of Benjamin Button* [Motion picture]. United States: Paramount Pictures & Warner Bros. Pictures.

Gavanski, I. & Wells, G.L. (1989). Counterfactual Processing of Normal and Exceptional Events. *Journal of Experimental Social Psychology, 25*, 314-325.

German, T. P., & Nichols, S. (2003). Children's counterfactual inferences about long and short causal chains. *Developmental Science, 6,* 514–523.

German, T.P. (1999). Children's causal reasoning: counterfactual thinking occurs for 'negative' outcome only. *Developmental Science, 2*, 442-447.

Gilovich, T. & Medvec, V.H. (1995). The Experience of Regret: What, When, and Why. *Psychological Review, 102*, 379-395.

Gilovich, T., Wang, R. F., Regan, D., & Nishina, S. (2003). Regrets of action and inaction across cultures. *The Journal of Cross Cultural Psychology, 34*, 61-71. doi: 10.1177/0022022102239155

Girotto, V., Legrenzi, P., & Rizzo, A. (1991). Event controllability in counterfactual thinking. *Acta Psychologica, 78*, 111-133.

Grant, C.M., Riggs, K.J., & Boucher, J. (2004). Counterfactual and Mental State Reasoning in Children with Autism. *Journal of Autism and Developmental Disorders, 34*, 177-188. 0162-3257/04/0400-0177/0

Guajardo, N.R., Parker, J., & Turley-Ames, K.J. (2009). Associations among false belief understanding, counterfactual reasoning, and executive function. *British Journal of Developmental Psychology, 29,* 681–702. doi:10.1348/026151008X357886.

Guajardo, N., & Turley-Ames, K. J. (2004). Preschoolers' generation of different types of counterfactual statements and theory of mind understanding. *Cognitive Development, 19,* 53–80.

Guttentag, R., & Ferrell, J. (2004). Reality compared with its alternatives: Age differences in judgments of regret and relief. *Developmental Psychology, 40,* 764–775. doi:10.1037/0012-1649.40.5.764.

Guttentag, R., & Ferrell, J. (2008). Children's understanding of anticipatory regret and disappointment. *Cognition and Emotion, 22*, 815– 832. doi:10.1080/02699930701541542

Hala, S. & Russell, J. (2001). Executive Control within Strategic Deception: A Window on Early Cognitive Development? Journal *of Experimental Child Psychology, 80*,112–141. doi:10.1006/jecp.2000.2627

Harris, P. L. (1997). On realizing what might have happened instead. *Polish Quarterly of Developmental Psychology, 3,*161–176. doi:10.1016/S0010-0277(96)00715-9.

Harris, P.L., German, T.P., & Mills, P. (1996). Children's use of counterfactual-thinking in causal reasoning. *Cognition, 61,* 233–259.

Hughes, C. (1996). Control of action and thought: Normal development and dysfunction in autism: A research note. *Journal of Child Psychology and Psychiatry, 37*, 229–236.

Johnson, M.K., & Sherman, S.J. (1990). Constructing and reconstructing the past and the future in the present. In E.T. Higgins & R.M. Sorrentino (Eds.), *Handbook of motivation and social cognition: Foundations of social behavior* (pp. 482-526). New York: Guilford Press.

Johnson-Laird, P.N. & Byrne, R.M.J. (2002). Conditionals: A Theory of Meaning, Pragmatics, and Inference. *Psychological Review, 109*, 646-678. DOI: 10.1037//0033-295X.109.4.646

Kahneman, D., & Tversky, A. (1982). The simulation heuristic. In D. Kahneman, P. Slovic, & A. Tversky (Eds.), *Judgment under uncertainty: Heuristics and biases* (pp. 201 – 208). New York: Cambridge University Press.

Kahneman, D. & Miller, D.T. (1986). Norm Theory: Comparing Reality to Its Alternatives. *Psychological Review, 93*, 136-153.

Komiya, A., Miyamoto, Y., Watabe, M., & Kusumi, T. (2011). Cultural grounding of regret: regret in self and interpersonal contexts. *Cognition and Emotion, 26*, 1121-1130. DOI: 10.1080/02699931.2010.516962

Kray, L.J., George, L.G., Liljenquist, K.A., Galinsky, A.D., Tetlock, P.E., & Roese, N.J., (2010). From What Might Have Been to What Must Have Been: Counterfactual Thinking Creates Meaning. *Journal of Personality and Social Psychology, 98*, 106-118. DOI: 10.1037/a0017905

Landman, J. (1993). *Regret: The persistence of the possible*. New York: Oxford University Press.

Leevers, H.J. & Harris, P.L. (2000). Counterfactual Syllogistic Reasoning in Normal 4-Year-Olds, Children with Learning Disabilities, and Children with Autism. *Journal of Experimental Child Psychology, 76*, 64 – 87. doi:10.1006/jecp.1999.2542

Leslie, A.M. (1994). *Pretending* and *Believing*: Issues in the theory of TOMM. *Cognition, 30*, 211-238.

Leslie, A.M. (1987). Pretense and Representation: The Origins of "Theory of Mind". *Psychological Review, 94*, 412-426.

Mandel, D.R. & Lehman, D.R. (1996). Counterfactual Thinking and Ascriptions of Cause and Preventability. *Journal of Personality and Social Psychology, 71*, 450-463.

Markman, K.D. & Tetlock, P.E. (2000). `I couldn't have known': Accountability , foreseeability and counterfactual denials of responsibility. *British Journal of Social Psychology, 39,* 313-325.

Markman, K.D., Gavanski, I., Sherman, S.J., & McMullen, M.N. (1993). The Mental Simulation of Better and Worse Possible Worlds. *Journal of Experimental Social Psychology, 29*, 87-109.

McCloy, R. & Byrne, R.M.J. (2000). Counterfactual thinking about controllable events. *Memory and Cognition, 28*, 1071-1078.

McCormack, T. & Hoerl, C. (2008). Temporal Decentering and the Development of Temporal Concepts. *Language Learning, 58*, 89-113. DOI: 10.1111/j.1467-9922.2008.00464.x

McEleny, A. & Byrne, R.M.J. (2006). Spontaneous counterfactual thoughts and causal explanations. *Thinking and Reasoning, 12*, 235-255. DOI: 10.1080/13546780500317897

Miller, D. T., Visser, P. S., & Staub, B. D. (2005). How surveillance begets perceptions of dishonesty. The case of the counterfactual sinner. *Journal of Personality and Social Psychology, 89*, 117-128.

Miyake, A., Friedman, N.P., Emerson, M.J., Witzki, A.H., & Howerter, A. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: a latent variable analysis. *Cognitive Psychology, 41*, 49–100. doi:10.1006/cogp.1999.0734

Morris, M.W. & Moore, P.C. (2000). The Lessons We (Don't) Learn: Counterfactual Thinking and Organizational Accountability after a Close Call. *Administrative Science Quarterly, 45*, 737-765.

Nigg, J.T. (2000).On inhibition/disinhibition in developmental psychopathology: views from cognitive and personality psychology and a working inhibition taxonomy. *Psychological Bulletin, 126,* 220–246.

O'Connor, E., McCormack, T., & Feeney, A. (2012). The development of regret. *Journal of Experimental Child Psychology, 111*, 120-127. DOI: 10.1016/j.jecp.2011.07.002

Perner, J., Sprung, M., & Steinkogler, B. (2004). Counterfactual conditionals and false belief: A developmental dissociation. *Cognitive Development, 19,* 179–201. doi:10.1016/j.cogdev.2003.12.001

Rafetseder, E., Cristi-Vargas, R., & Perner, J. (2010). Counterfactual reasoning: Developing a sense of "nearest possible world". *Child Development, 81*, 376–389. doi:10.1111/j.1467-8624.2009.01401.x

Rafetseder, E. & Perner, J. (2014). Counterfactual Reasoning: Sharpening Conceptual Distinctions in Developmental Studies. *Child Development Perspectives, 8*, 54-58. DOI: 10.1111/cdep.12061

Rafetseder, E., & Perner, J. (2012). When the alternative would have been better: Counterfactual reasoning and the emergence of regret. *Cognition and Emotion, 26*, 800–819. doi:10.1080/02699931-.2011.619744

Rafetseder, E. & Perner, J. (2010). Is reasoning from counterfactual antecedents evidence for counterfactual reasoning? *Thinking and Reasoning, 16*, 131-155. doi:10.1080/13546783.2010.488074.

Rafetseder, E., Schwitalla, M., & Perner, J. (2013). Counterfactual reasoning: From childhood to adulthood. *Journal of Experimental Child Psychology, 114*, 389–404. doi:10.1016/j.jecp.2012.10.010

Richards, C. & Sanderson, J.A. (1999). The role of imagination in facilitating deductive reasoning in 2-, 3- and 4-year-olds. *Cognition, 72*, B1-B9.

Riggs, K.J., Peterson, D.M., Robinson, E.J., & Mitchell, P. (1998). Are errors in false belief tasks symptomatic of a broader difficulty with counterfactuality? *Cognitive Development, 13,* 73–90. 10.1016/S0885-2014(98)90021-1

Riggs, K.J. & Beck, S.R. (2007). Thinking developmentally about counterfactual possibilities. Commentary on Byrne R.M.J. (2005) *The Rational Imagination. Behavioral Brain Sciences, 30*, 463. doi:10.1017/S0140525X07002695

Robinson, E.J. & Beck, S.R. (2000). What is difficult about counterfactual reasoning? In P. Mitchell and K. Riggs (Eds.). *Children's Reasoning and the Mind* (pp. 101–119). Hove, UK: Psychology Press.

Roese, N.J. (1999). Counterfactual Thinking and Decision Making. *Psychonomic Bulletin and Review, 6*, 570-578.

Roese, N.J. (1997). Counterfactual Thinking. *Psychological Bulletin, 121*. 133-148.

Roese, N.J. (1994). The Functional Basis of Counterfactual Thinking. *Journal of Personal and Social Psychology, 66*, 805-818.

Roese, N.J. & Olson, J.M. (1995). Outcome Controllability and Counterfactual Thinking. *Personality and Social Psychology Bulletin, 21*, 620-628. DOI: 10.1177/0146167295216008

Roese, N.J., Sana, L.J., & Galinsky, A.D. (2006). The Mechanics of Imagination: Automaticity and Control in Counterfactual Thinking. In Hassin, R.R., Uleman, J.S., & Bargh J.A. (Eds.). *The New Unconscious* (pp. 138-170). New York: Oxford University Press.

Roese, N.J. & Summerville, A. (2005). What We Regret Most…and Why. *Personality and Social Psychology Bulletin, 31,* 1273-1285. DOI: 10.1177/0146167205274693

Sanna, L.J. & Turley, K.J. (1996). Antecedents to Spontaneous Counterfactual Thinking: Effects of Expectancy Violation and Outcome. *Personality and Social Psychology Bulletin, 22*, 906-919. DOI: 10.1177/0146167296229005

Santamaria, C., Espino, O., & Byrne, R.M.J (2005). Counterfactual and Semifactual Conditionals Prime Alternative Possibilities. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31*, 1149, 1154. DOI: 10.1037/0278-7393.31.5.1149

Scott, F.J. (1999). 'If pigs could fly': A test of counterfactual reasoning and pretence in children with autism. *British Journal of Developmental Psychology, 17*, 349–362.

Simpson, A., Riggs, K.J., Beck, S.R., Gorniak, S.L., Wu, Y., Abbott, D., & Diamond, A. (2011). Refining the understanding of inhibitory processes: how response prepotency is created and overcome. *Developmental Science, 15*, 62-73. DOI: 10.1111/j.1467-7687.2011.01105.x

Smallman, R. & Roese, N.J. (2009). Counterfactual thinking facilitates behavioral intentions. *Journal of Experimental Social Psychology, 45*, 845-852. doi: 10.1016/j.jesp.2009.03.002

Smith, M., Apperly, I. A., & White, V. (2003). False belief reasoning and the acquisition of relative clause sentences. *Child Development, 74*, 1709–1719.

Sweeny, K. & Vohs, K.D. (2012). On Near Misses and Completed Tasks: The Nature of Relief. *Psychological Science, 23,* 464-468. DOI: 10.1177/0956797611434590

Thompson, V.A., & Byrne, R.M. (2002). Reasoning Counterfactually: Making Inferences About Things That Didn't Happen. *Journal of Experimental Psychology, 28*, 1154-1170. DOI: 10.1037//0278-7393.28.6.1154

Ursu, S. & Carter, C.S. (2005). Outcome representations, counterfactual comparisons and the human orbitofrontal cortex: Implications for neuroimaging studies of decision-making. *Cognitive Brain Research, 23*, 51-60. doi:10.1016/j.cogbrainres.2005.01.004

Van de Ven, N., Zeelenberg, M., & Pieters, R. (2009). Leveling Up and Down: The Experiences of Benign and Malicious Envy. *Emotion, 9*, 419-429. DOI: 10.1037/a0015669

Van Dijk, E. & Zeelenberg, M. (2005). On the psychology of 'if only': Regret and the comparison between factual and counterfactual outcomes. *Organizational Behavior and Human Decision Processes, 97*, 152-160. doi:10.1016/j.obhdp.2005.04.001

Van Hoeck, N., Ma, N., Ampe, L., Baetens, K., Vandekerckhove, M., & Van Overwalle, F. (2013). Counterfactual Thinking: An fMRI Study on Changing the Past for a Better

Future. *Social Cognitive and Affective Neuroscience, 8*, 556-564. doi: 10.1093/scan/nss03

Walsh, C.R. & Byrne, R.M.J. (2004). Counterfactual thinking: The temporal order effect. *Memory and Cognition, 32*, 369-378.

Weisberg, D. P., & Beck, S. R. (2010). Children's thinking about their own and others' regret and relief. *Journal of Experimental Child Psychology, 106,* 184–191. doi:10.1016/j.jecp.2010.02.005

Weisberg, D. P., & Beck, S. R. (2012). The development of children's regret and relief. *Cognition and Emotion, 26,* 820–835. doi:10.1080/02699931.2011.621933

Wellman, R.J. & Sugarman, D.B. (2006). The Impact of Personal Expectations on Counterfactual Thinking About Life and Death Medical Decisions. Basic and Applied Social *Psychology, 28*, 81-89. DOI: 10.1207/s15324834basp2801_7

Williams, C.W., Lees-Haley, P.R., & Brown, R.S. (1993). Human Responses to traumatic events: An Integration to Counterfactual Thinking, Hindsight Bias, and Attribution Theory. *Psychological Reports, 72*, 483-494.

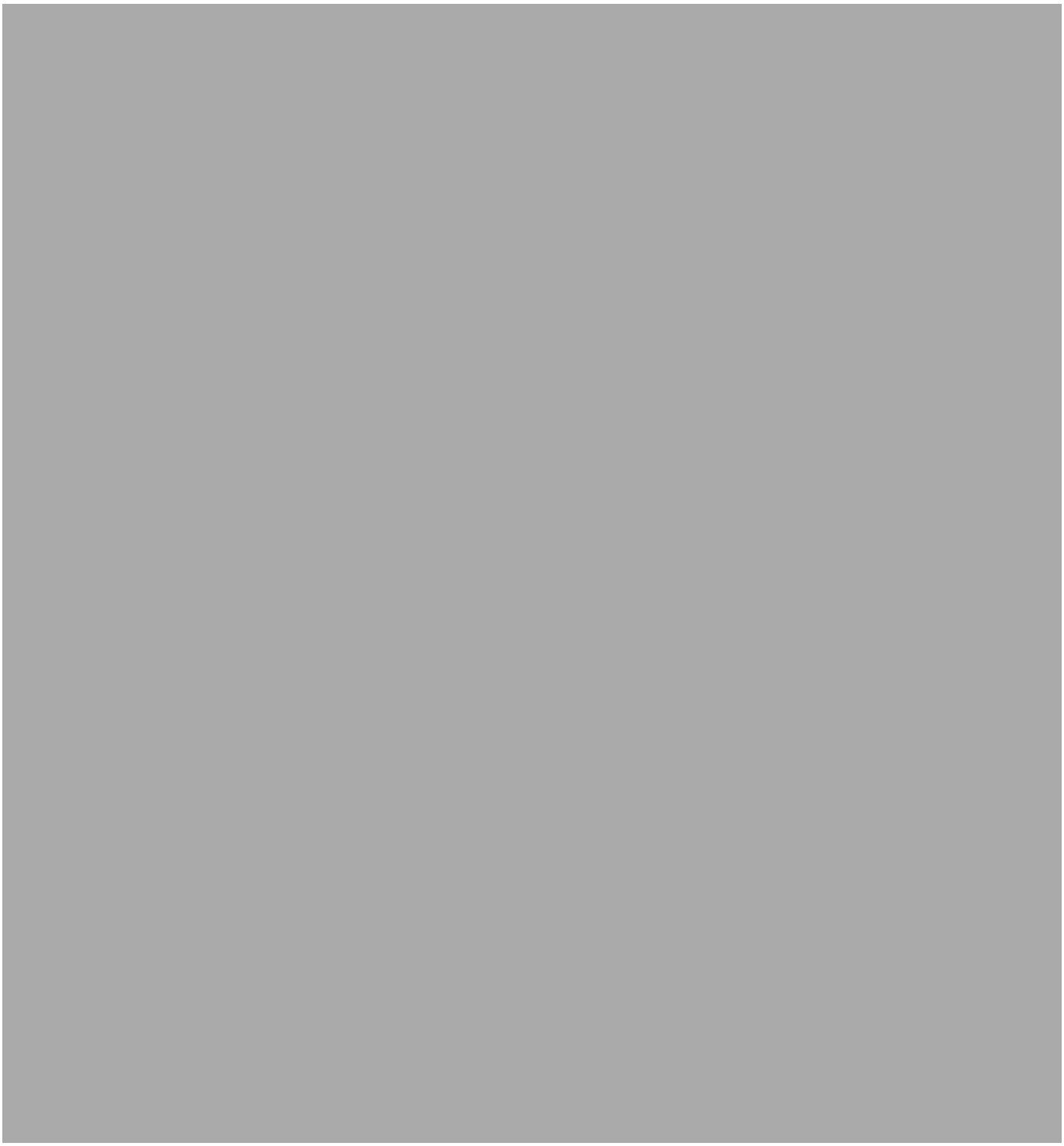
Zeelenberg, M., van Dijk, W.W., Manstead, A.S.R., & der Pligt, J. (1998). The Experience of Regret and Disappointment. *Cognition and Emotion, 12*, 221-230.

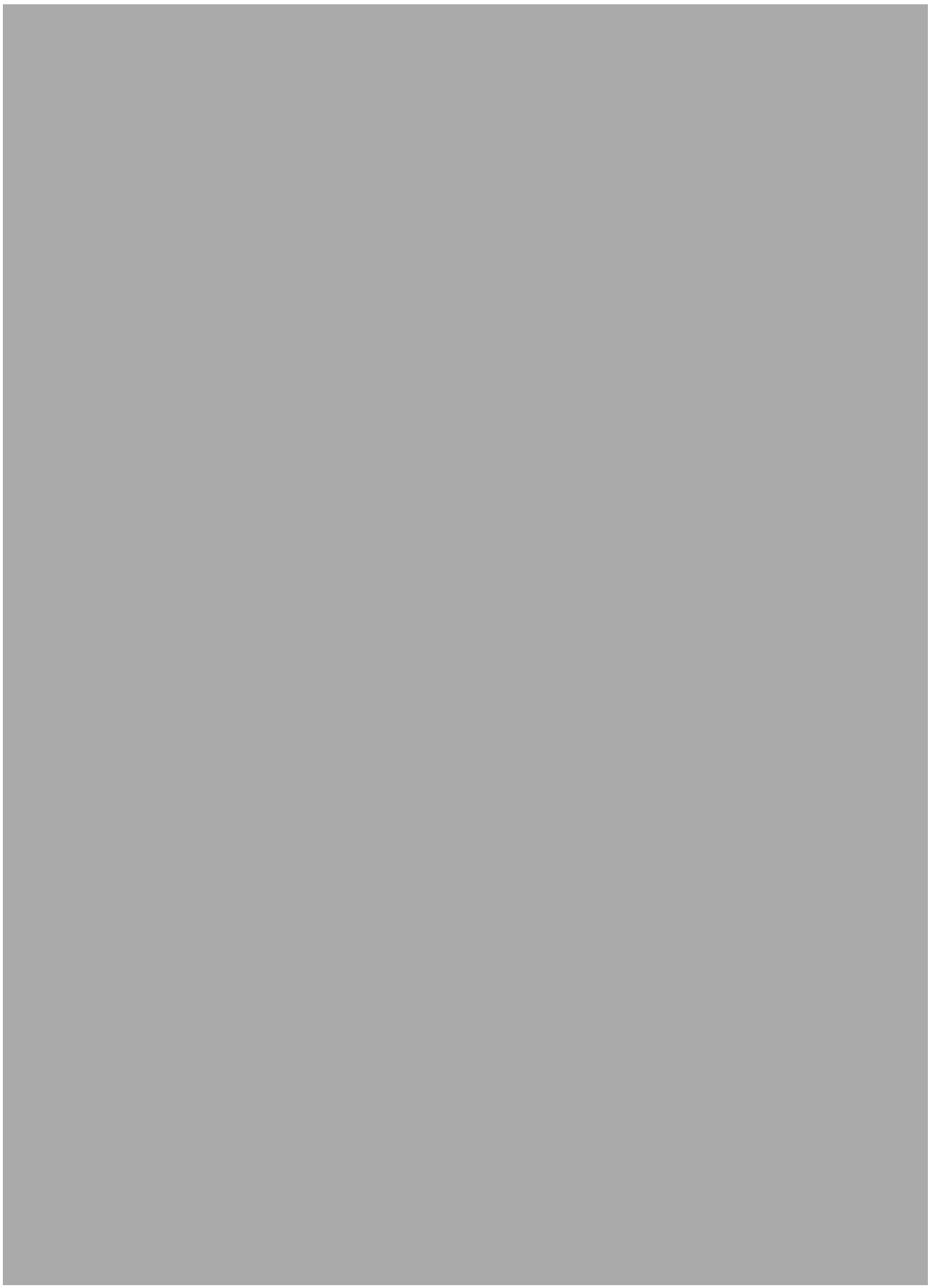
Zeelenberg, M., van Dijk, W.W., & Manstead, A.S.R. (1998). Reconsidering the Relation between Regret and Responsibility. *Organizational Behavior and Human Decision Processes, 74*, 254-272.

APPENDIX 1

Example of written consent forms

Below we present one consent form obtained form a Romanian school and a British preschool

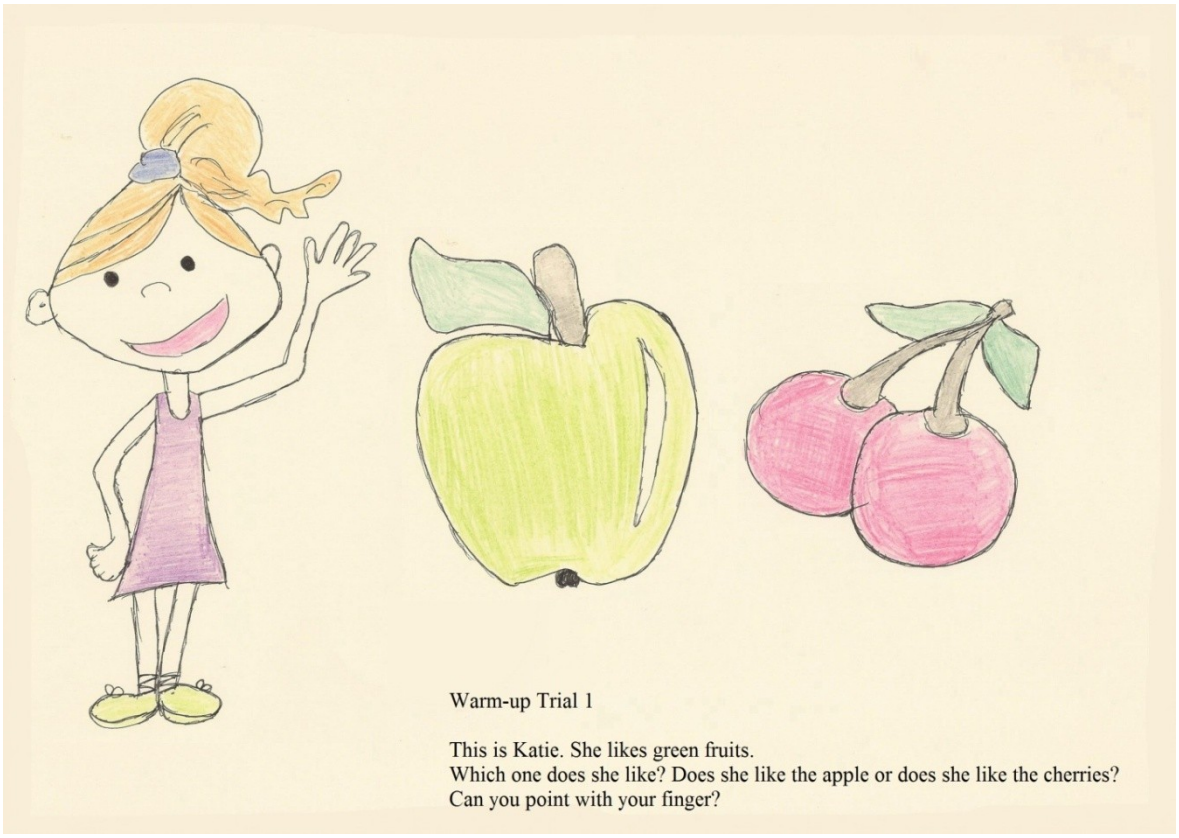




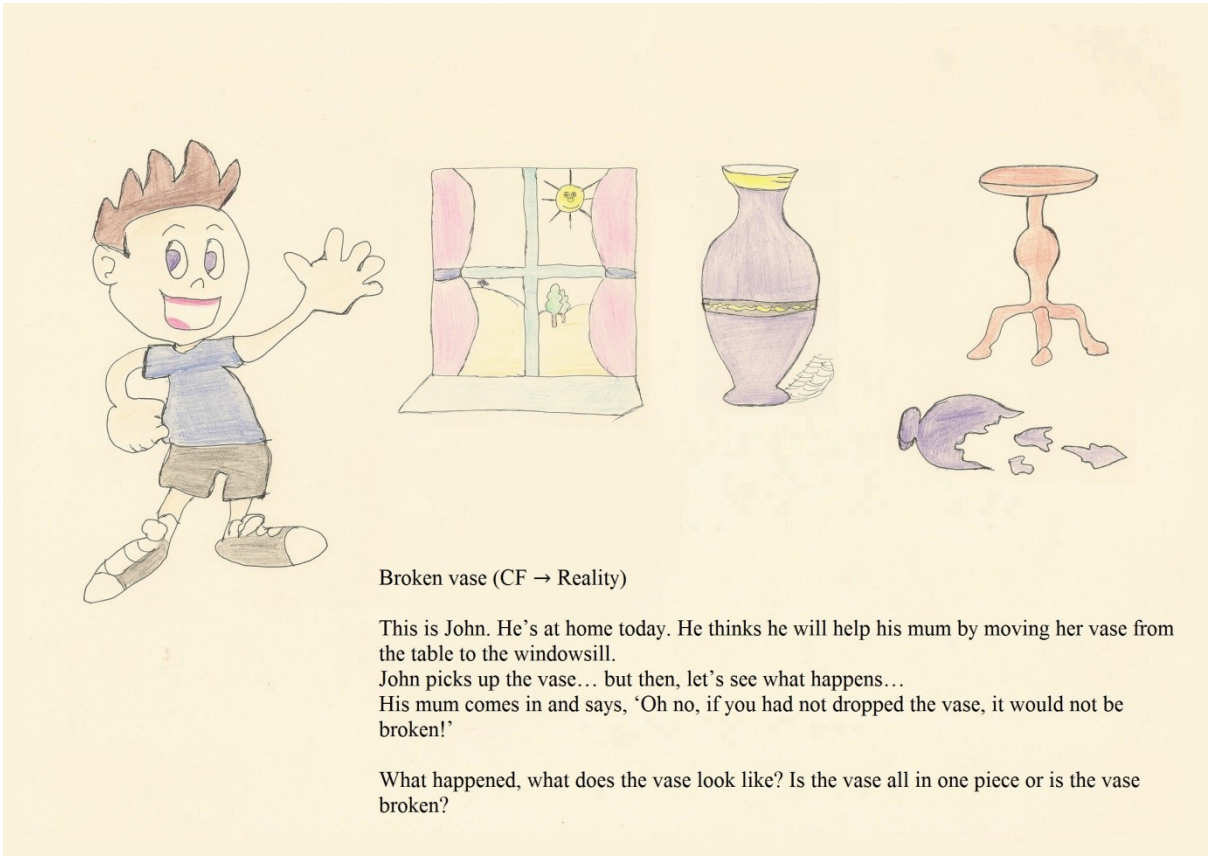
APPENDIX 2

Examples of warm-up trials and counterfactual stories used in Experiment 1

1) Warm-up Trial 1 – Finger mode



2) Broken Vase story used in counterfactual-to-reality trial for both arrow and finger pointing response mode.



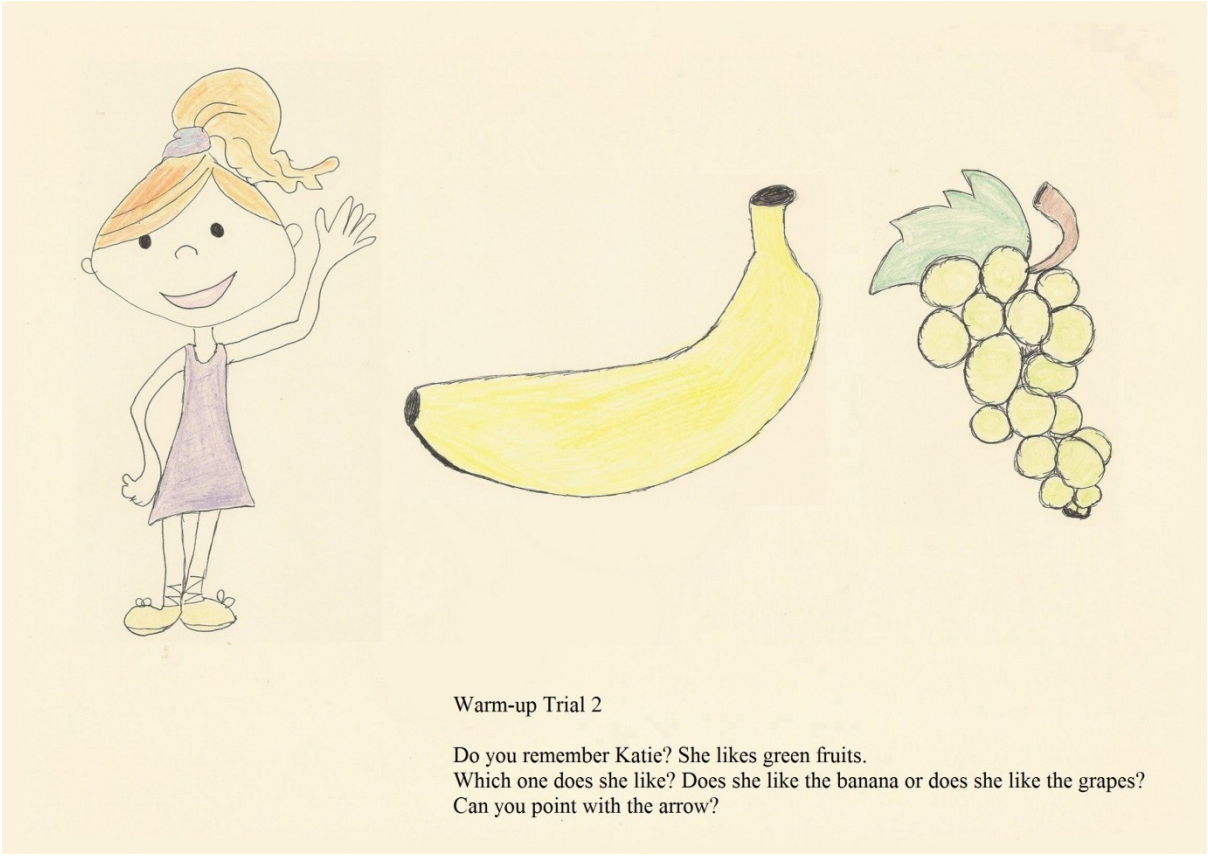
3) Forgotten Present story used in reality-to-counterfactual trial for both arrow and finger pointing response mode.

Forgotten present (Reality → CF)

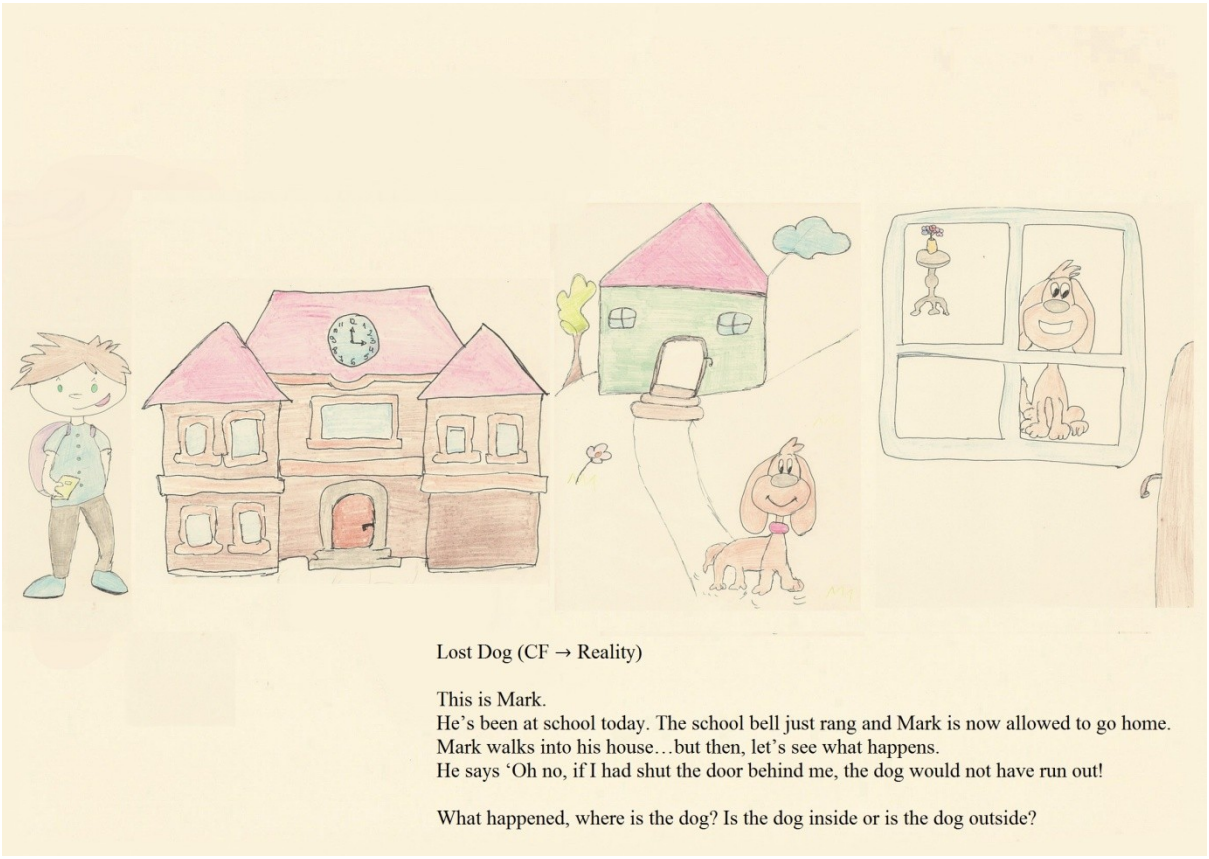
This is Emma.
She is going to her best friend's birthday party. She is wearing her best clothes and there are lots of balloons.
Emma goes in the living room to see her friend…but then, she realizes she's forgotten the present and her friend cannot open it.
She says 'Oh no!'

Let's think, what if Emma had remembered the present, would her friend have the present or would her friend not have the present?

4) Warm-up Trial 2 – Pointing with arrow



5) Lost Dog story used in counterfactual-to-reality trial for both arrow and finger pointing mode.

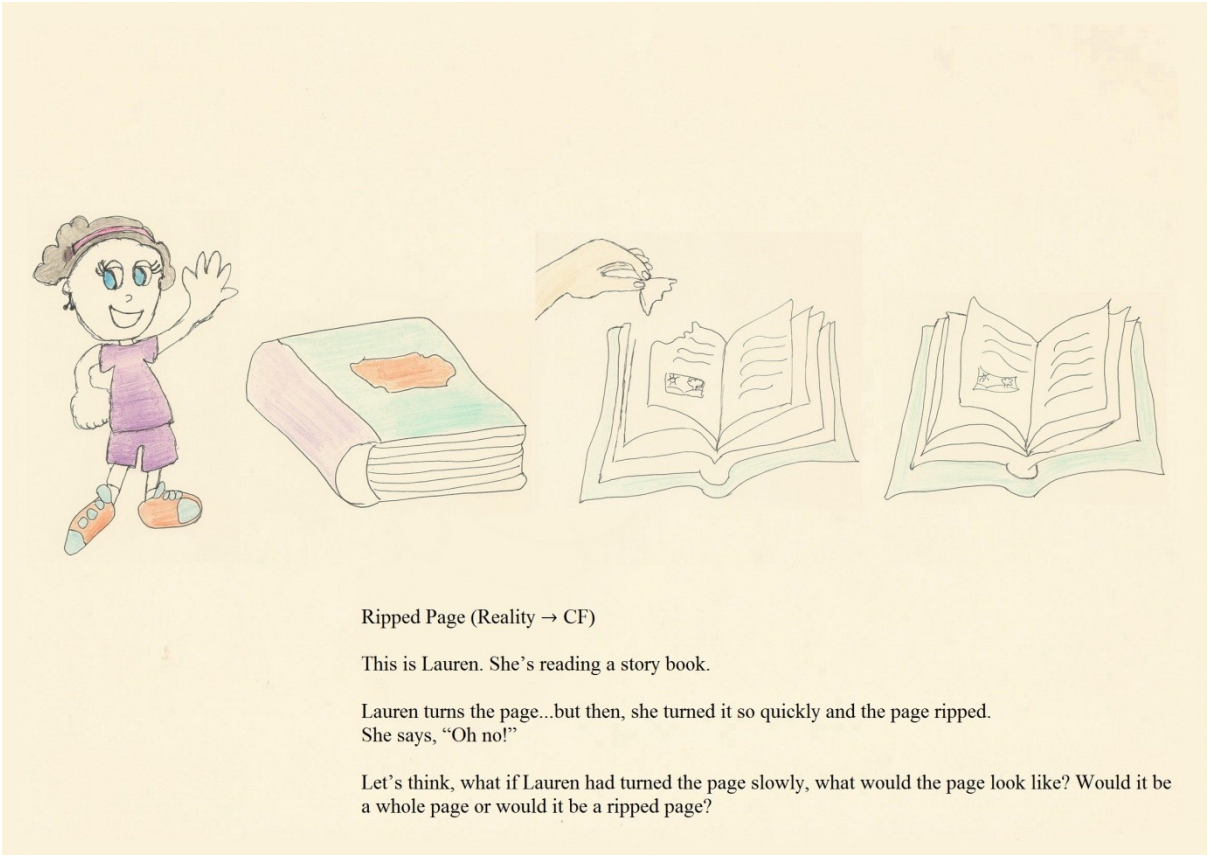


Lost Dog (CF → Reality)

This is Mark.
He's been at school today. The school bell just rang and Mark is now allowed to go home.
Mark walks into his house…but then, let's see what happens.
He says 'Oh no, if I had shut the door behind me, the dog would not have run out!

What happened, where is the dog? Is the dog inside or is the dog outside?

6) Ripped page story used in reality-to-counterfactual trial for both arrow and finger pointing response mode.



Ripped Page (Reality → CF)

This is Lauren. She's reading a story book.

Lauren turns the page...but then, she turned it so quickly and the page ripped.
She says, "Oh no!"

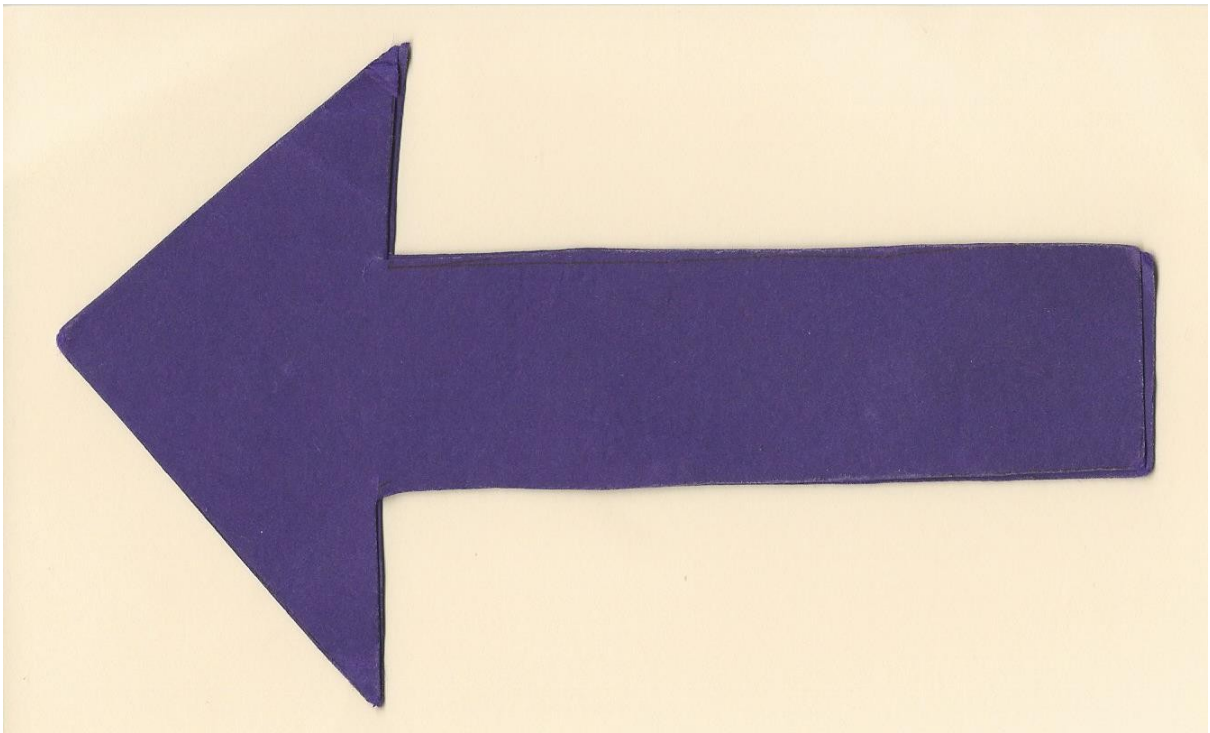
Let's think, what if Lauren had turned the page slowly, what would the page look like? Would it be a whole page or would it be a ripped page?

Above we presented a selection of the stories we used in our Experiment 1. All these stories had a Counterfactual-to-reality and a Reality-to-counterfactual version and could be presented either in the pointing with finger or in the pointing with arrow version.

In the pointing with finger versions children heard: ‘I am going to tell you some stories and I am going to ask you some questions about them. When you answer the questions I want you to point at the pictures with your finger.’

In the pointing with arrow versions children were told: Now for the rest of the stories we will play something different. Now when you answer the questions I want you to point at the pictures with this arrow.

Below we present an image of the arrow that we used in our two studies of Experiment 1



APPENDIX 3

Stories used in Experiment 2. Below each story we attached pictures of the dolls and props used.

1. a. Getting wet story in undiscriminating version

This is Danny (presenting Danny) and this is his friend Andy (pointing at Andy).

One day, Danny was outside in the park after it had been raining. There were puddles everywhere. He was waiting for his friend Andy.

Behind him there was a big puddle. His friend arrived from the opposite direction and decided to play a joke on him. Andy ran and jumped into the puddle splashing water all over and getting poor Danny really wet.

Danny said: Oh no!!! I cannot play now, I will have to go back home and get some dry clothes.

Now question: Are Danny's clothes wet now?

Before question: Were Danny's clothes wet before?

Standard counterfactual: If Andy had not jumped into the puddle, would Danny's clothes be wet or dry?

1. b. Getting wet story in the discriminating versions

This is Danny (presenting Danny) and these are his friend Andy (pointing at Andy) and Ryan (pointing at Ryan).One day, Danny was outside in the park after it had been raining. There were puddles everywhere.

He was waiting for his friends Ryan and Andy. Behind him there was a big puddle. His friends arrived from the opposite direction and decided to play a joke on him.

Andy ran and jumped into the puddle splashing water all over and getting poor Danny really wet. Then straight after Ryan jumped as well in the puddle and splashed Danny.

Danny said: Oh no!!! I cannot play now, I will have to go back home and get some dry clothes.

Now question: Are Danny's clothes wet now?

Before question: Were Danny's clothes wet before?

Experiment questions

Standard: If Andy had not jumped into the puddle, would Danny's clothes be wet or dry?

Just: What if **just** Andy had not jumped into the puddle; would Danny's clothes be wet or dry?

2. a. Painting story in undiscriminating version

This is Peter (presenting Peter).

One day Peter was playing. Peter got bored and decided to draw something. He liked drawing very much.

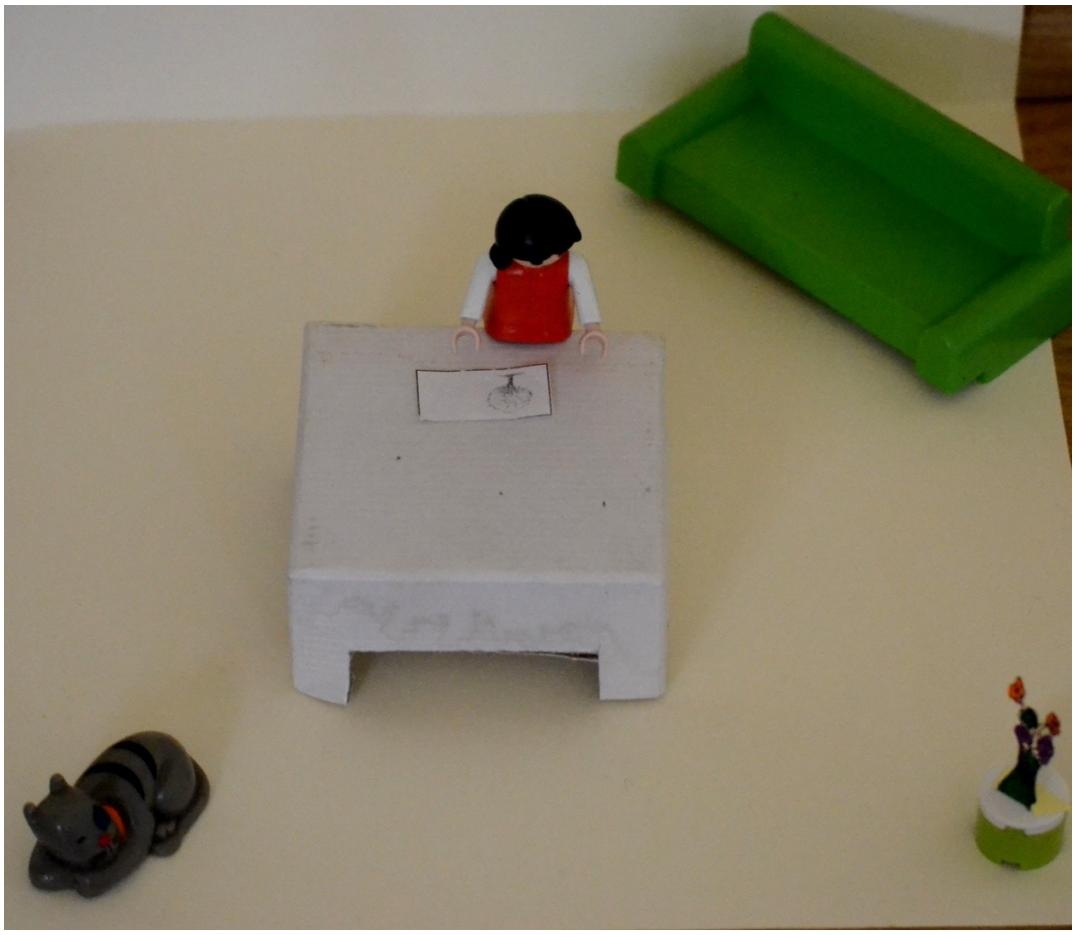
He found a clean piece of paper and some crayons. Very cheery, he ran to the table and started drawing a tree.

Now question: Is the piece of paper clean now?

Before question: Was the paper clean before?

Experiment questions

Standard counterfactual: If Peter had not have drawn on the paper, would the paper be clean or drawn on?



2. b. Painting story in the discriminating versions

This is Peter (pointing at Peter) and this is his friend Joey (pointing at Joey).

One day Peter and Joey were playing. Peter got bored and decided to draw something. He liked drawing very much.

He found a clean piece of paper and some crayons. Very cheery, he ran to the table and started drawing a tree.

Joey wanted to draw something as well. He took one crayon and drew a sun on Peter's piece of paper.

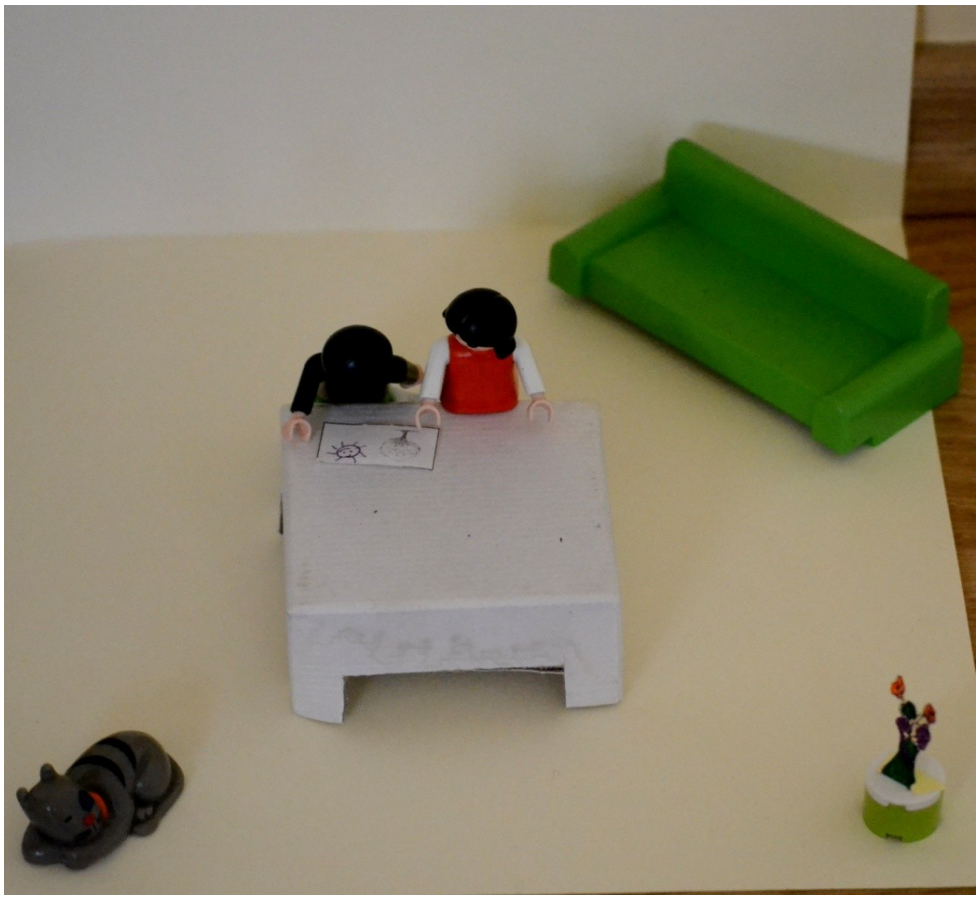
Now question: Is the piece of paper clean now?

Before question: Was the paper clean before?

Experiment questions

Standard: If Peter had not have drawn on the paper, would the paper be clean or drawn on?

Just: If **just** Peter had not have drawn on the paper, would the paper be clean or drawn on?



3. a. Sleeping baby in undiscriminating version

This is Eddie (presenting Eddie) and this is his baby sister.

One day Eddie came home from school and had found his Mum in the kitchen. She was cooking.

Mum said: I will call you when dinner is ready. Dad is still at work and your baby sister is sleeping.

Eddie went into his room. After a little while he started playing his drums and made a loud noise. Bum-bum!!! The baby woke up and started crying.

Mum said 'oh no!'

Before: Was the baby sleeping before?

Now: Is the baby sleeping now?

Standard counterfactual: What if Eddie had not have played the drums, would the baby be awake or asleep?

3. b. Sleeping baby story in the discriminating versions

This is Eddie (presenting Eddie) and this is his baby sister.

One day Eddie came home from school and had found his Mum in the kitchen. She was cooking.

Mum said: I will call you when dinner is ready. Dad is still at work and your baby sister is sleeping.

Eddie went into his room. After a little while he started playing his drums and made a loud noise. Bum-bum!!! Then straight after Mum dropped a teapot in the kitchen. It made a big crash. Bang!!!

The baby woke up and started crying.

Mum said 'oh no!'

Before: Was the baby sleeping before?

Now: Is the baby sleeping now?

Standard: What if Eddie had not have played the drums, would the baby be awake or asleep?

Just: What if **just** Eddie had not made any noise, would the baby be awake or asleep?

4. a. Dirty floor story in undiscriminating version

This is Suzie (presenting Suzie).

One day, Suzie was playing in the garden after it had been raining. The ground was really muddy. Mum came to the door.

'Suzie!' she called. 'Come on inside and drink your juice.'

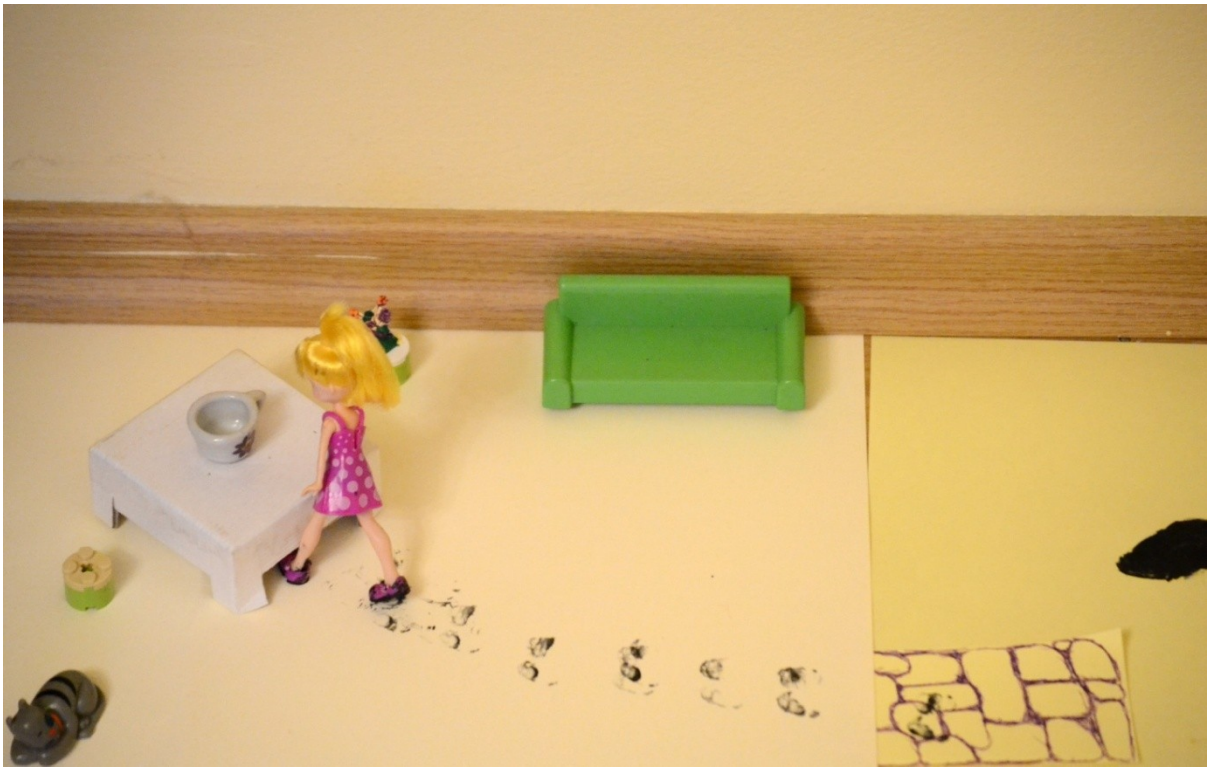
Look the floor is nice and clean!

Suzie ran into the house. She reached the table and grabbed the cup. In her hurry, she forgot to take her shoes off and she made the floor all muddy. Mum said: Oh no!!!

Before: Was the floor clean before?

Now: Is the floor clean now?

Standard counterfactual: What if Suzie had taken her shoes off would the floor be dirty or clean?



4. b. Dirty floor in the discriminating versions

This is Suzie (presenting Suzie) and this is her sister Katie (presenting Katie).

One day, Suzie and Katie were playing in the garden after it had been raining. The ground was really muddy. Their mum came to the door.

'Suzie! Katie!' she called. 'Come on inside and drink your juice.'

Look the floor is nice and clean!

Suzie ran into the house and Katie followed her immediately. They reached the table and grabbed the cups. In their hurry, they forgot to take their shoes off and they made the floor all muddy. Their mum said: Oh no!!!

Before: Was the floor clean before?

Now: Is the floor clean now?

Standard: What if Suzie had taken her shoes off would the floor be dirty or clean?

Just: What if **just** Suzie had taken her shoes off would the floor be dirty or clean?