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Counterfactual thinking and false belief: The role of executive function

Stefane Drayton [a,*], Kandi J. Turley-Ames [a], Nicole R. Guajardo [b]

[a] *Department of Psychology, Idaho State University, Pocatello, ID 83209, USA*
[b] *Department of Psychology, Christopher Newport University, Newport News, VA 23693, USA*

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ABSTRACT

The purpose of the current study was to examine further the relationship between counterfactual thinking and false belief (FB) as examined by Guajardo and Turley-Ames (*Cognitive Development, 19* (2004) 53–80). More specifically, the current research examined the importance of working memory and inhibitory control in understanding the relationship between counterfactual thinking and FB. Participants were 3-, 4-, and 5-year-olds ($N = 76$). Counterfactual thinking statements generated accounted for significant variance in FB performance beyond age and language. Working memory and inhibitory control each partially mediated the relationship between counterfactual thinking and FB performance. The maturation of executive functioning skills is important in children's developing understanding of counterfactual reasoning and FB.

Introduction

Navigating social situations requires adults and children to interact with others, infer others' thoughts and feelings, and make decisions based on this information. Such social interaction includes both counterfactual thinking and theory of mind (ToM). The relationship between counterfactual thinking and ToM, and more specifically false belief (FB) understanding, has been documented (e.g., Guajardo & Turley-Ames, 2004; Riggs, Peterson, Robinson, & Mitchell, 1998). As of late, researchers have become interested in the reason for this relationship, and several have suggested the importance of executive function (German & Nichols, 2003; Guajardo, Parker, & Turley-Ames, 2009; Guajardo & Turley-Ames, 2004; Müller, Miller, Michalczyk, & Karapinka, 2007). Inhibitory control, cognitive

* Corresponding author. Fax: +1 208 233 0159.
E-mail address: draystef@yahoo.com (S. Drayton).

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flexibility, and temporary storage all have been shown to predict counterfactual thinking (e.g., Beck, Riggs, & Gorniak, 2009; Guajardo et al., 2009) and FB performance (Carlson & Moses, 2001; Carlson, Moses, & Breton, 2002; Carlson, Moses, & Hix, 1998; Davis & Pratt, 1995; Frye, Zelazo, & Palfai, 1995). Thus, executive function – namely inhibitory control and working memory – might, in part, account for the relationship between counterfactual thinking and FB. The current study had two purposes, namely to (a) replicate and clarify the relationship between counterfactual thinking and FB and (b) examine the role of executive function (i.e., working memory and inhibitory control) in this relationship.

Counterfactual thinking

Counterfactual thinking involves considering events inconsistent with reality (e.g., Harris, German, & Mills, 1996; Kavanaugh & Harris, 1999; Riggs et al., 1998) and often includes "if…only" thinking in which one typically engages when an outcome is known (Roese, 1994). For instance, if a child breaks his or her favorite color of crayon, the child might think, "If only I had not pushed so hard." Counterfactual thinking requires a realization that an event could have occurred differently, and it may include the ability to compare reality with one or more hypothetical alternatives (e.g., Guajardo & Turley-Ames, 2004; Riggs et al., 1998; Roese, 1994). Counterfactual thinking emerges as early as 1½ years of age with pretend play (Richards & Sanderson, 1999) and the development of words such as "almost" and "nearly" (Kahneman & Varey, 1990). Success on antecedent and consequent counterfactual tasks begins around 3 years of age (Beck et al., 2009; German & Nichols, 2003; Guajardo & Turley-Ames, 2004; Riggs et al., 1998).

Guajardo and Turley-Ames (2004) distinguished between counterfactual thinking antecedent tasks and consequent tasks. Antecedent counterfactual tasks involve identifying alternative antecedents that would change a consequence. Specifically, a child is asked to imagine himself or herself in a situation and then is asked what he or she could have done to change the consequence. For example, a girl is asked to imagine that she is playing outside and becomes thirsty, so she comes into the kitchen to get a drink of juice. She left her muddy shoes on, stepped over the doormat, and so got the floor dirty. The child then is asked what she could have done to not get the floor dirty (e.g., take shoes off, wipe shoes on the doormat). In contrast, consequent tasks involve identifying outcomes that would result from a specific antecedent. For example, in Riggs and colleagues' (1998) study, participants were told that Peter is not feeling very well and goes to bed. Next, the phone rings, and Peter is asked to come and help put out a fire. Peter gets out of bed and goes to help. Next, children are asked, "If there had not been a fire, where would Peter be?" Children are correct when they identify a logical consequence of the antecedent (i.e., Peter would be in bed).

Both antecedent and consequent tasks require children to suppress their knowledge of current reality, yet there seem to be differences as well. Given these differences, it seems possible that they differ in terms of executive demands. The antecedent tasks require children to both hold in mind the consequent of the action and develop possible antecedents to change the consequent. The consequent tasks seem less cognitively taxing because children are required only to hold in mind the antecedent while considering the consequent information. However, it is unclear from the literature so far whether this is indeed the case.

Counterfactual thinking and false belief

Riggs and colleagues (1998) and Guajardo and Turley-Ames (2004) argued that counterfactual thinking could account for FB performance because children must be able to consider alternatives to reality to pass an FB task. For example, on the classic unexpected change task (Wimmer & Perner, 1983), they must be able to consider how a situation could be different to understand that Maxi could think that the chocolate is in the blue cabinet even though it is in the red cabinet. Indeed, across studies, counterfactual thinking accounted for 3–24% of the variance in FB performance (Guajardo & Turley-Ames, 2004; Perner, Sprung, & Steinkogler, 2004; Riggs et al., 1998). Moreover, German and Nichols (2003) found that children's generation of counterfactuals on tasks with medium and long chains (with two or three steps from the cause) predicted children's FB performance, whereas shorter chains did not, perhaps because medium and long counterfactual chains and FB tasks make similar demands on executive function.

Although several researchers have observed the relationship between counterfactual thinking and FB (e.g., Guajardo & Turley-Ames, 2004; Guajardo et al., 2009; Peterson & Bowler, 2000; Peterson & Riggs, 1999; Riggs et al., 1998), an explanation for this relationship is uncertain. Several possible explanations include "aboutness" (Perner, 2000), modified derivation (Peterson & Riggs, 1999), and general limitations in counterfactual thinking ability (Riggs et al., 1998). Although each of these theories has received some support (see, e.g., Perner, 2000; Perner, Sprung, & Steinkogler, 2003; Peterson & Bowler, 2000; Peterson & Riggs, 1999; Riggs et al., 1998), others have questioned the extent to which these concepts can, or do, explain this relationship. For instance, Perner and colleagues (2003) found that although modified derivation may be necessary for counterfactual thinking, it was not necessary for FB understanding. Given limitations in these possible explanations, other researchers have suggested that working memory and/or inhibitory control may provide a more complete explanation for the relationship between counterfactual thinking and FB (German & Nichols, 2003; Guajardo & Turley-Ames, 2004; Müller et al., 2007).

Executive function, counterfactual thinking, and false belief

Executive function is a theorized cognitive system that controls and manages other cognitive processes, including flexibility of thought, planning, inhibition, and coordination and integration of information (Baddeley, 1996). Increases in strategy use, long-term knowledge (i.e., experience), and central executive control (Pickering, 2001) and decreases in resource demands (Engle, Carullo, & Collins, 1991) are reflective of a general maturation of executive functioning. The research on executive function, counterfactual thinking, and FB has focused largely on working memory and inhibitory control, both of which undergo much developmental change during the preschool years (e.g., Carlson, 2005; Gathercole, Pickering, Ambridge, & Wearing, 2004). Thus, the current study focused on these two aspects of executive function.

According to one theory, working memory is a multiunit storage and processing system (Baddeley, 1996) responsible for several executive functions, whereas inhibitory control is a specialized executive function that allows control of information processing by suppressing or reallocating attention. Both working memory and inhibitory control have been associated with FB performance in previous research (Carlson & Moses, 2001; Carlson et al., 1998; Carlson et al., 2002; Davis & Pratt, 1995; Gordon & Olson, 1998; Müller et al., 2007). For example, Davis and Pratt (1995) found that backward digit span predicted preschool-aged children's FB performance after controlling for age and language. Similarly, Carlson and colleagues (1998) found that inhibitory control was related to performance on a deceptive pointing task. However, inhibitory control might be more important than working memory for FB performance. Carlson and colleagues (2002) found that the relationship between working memory and FB was no longer significant after controlling for age and IQ, but inhibitory control continued to account for unique variance in FB performance.

Research on the relationship between counterfactual thinking and working memory or inhibitory control is limited with both adults and children (e.g., Goldinger, Kleider, Azuma, & Beike, 2003; Guajardo et al., 2009; Müller et al., 2007; Turley-Ames & Whitfield, 2000), and only one study to date has examined counterfactual thinking and inhibitory control (Beck et al., 2009). Goldinger and colleagues (2003) found that adults' counterfactual judgments were automatically processed except when memory load was varied. When under a relatively high memory load, counterfactuals were processed in a more controlled manner. Similarly, Turley-Ames and Whitfield (2000) observed that counterfactuals required more effortful processing in certain situations. More specifically, adults with less working memory capacity, or fewer cognitive resources, spent more time processing counterfactual statements and were slower to respond to certain types of counterfactual statements. By extension, it might be that some children, particularly younger children who are limited in working memory, may behave like adults with fewer resources, exhibiting processing deficits that affect both counterfactual thinking and FB.

Additional work has been conducted with young children. Beck and colleagues (2009) provided initial information on the degree to which working memory and inhibitory control account for variance in consequent counterfactual reasoning performance (i.e., syllogisms and conditionals). Although inhibitory control and working memory were correlated with performance on most of the counterfactual tasks, only inhibitory control predicted counterfactual thinking when language, working memory, and inhibitory control were entered into the regression. It is not yet known, however, how both working memory and inhibitory control predict counterfactual performance on antecedent counterfactual tasks.

Müller and colleagues (2007) examined whether working memory accounted for the relationship between counterfactual thinking and FB. Counterfactual thinking explained a significant amount of variance in FB, and this relationship remained after controlling for age and working memory. They concluded that the relationship between counterfactual thinking and FB was not based solely on working memory. Similarly, Guajardo and colleagues (2009) examined executive function as a possible mediator in the relationship between counterfactual thinking and FB. Contrary to Müller and colleagues (2007), they found that working memory, as well as representational flexibility, partially mediated the relationship between counterfactual thinking and FB performance. Moreover, counterfactual thinking did not account for unique variance in FB performance beyond age, language, working memory, and representational flexibility.

These two attempts to explain the relationship between counterfactual thinking and FB may have yielded different conclusions because of the working memory tasks included or counterfactual thinking tasks used. Müller and colleagues (2007) measured working memory with a counting and labeling task (Gordon & Olson, 1998), whereas Guajardo and colleagues (2009) used backward word span, backward digit span (Davis & Pratt, 1995), and counting and labeling (Gordon & Olson, 1998). It is possible that the inclusion of a range of working memory tasks led to different results. Müller and colleagues (2007), like Beck and colleagues (2009), used consequent tasks, whereas Guajardo and colleagues (2009) used antecedent tasks. Perhaps antecedent tasks place greater demands on working memory.

In conclusion, working memory and inhibitory control develop around the same time as FB and counterfactual thinking, increasing between 2 and 5 years of age. Research has provided evidence of relationships between each FB and counterfactual thinking and both working memory and inhibitory control, yet the degree to which these variables account for the relationship between counterfactual thinking and FB is less clear. No one to date has examined how specific components of executive functioning might be related to counterfactual thinking and FB performance.

The current study

The current study served, in part, to replicate Guajardo and Turley-Ames (2004) and clarify the relationship between counterfactual thinking and FB performance. Past research has reported differences in the levels of variance accounted for in this relationship, and so clarification was needed. The relationship was assessed with multiple FB tasks (i.e., unexpected change, unexpected contents, and deception) and multiple measures of counterfactual thinking. Both antecedent and consequent counterfactual tasks were included (see Guajardo & Turley-Ames, 2004; Riggs et al., 1998).

Importantly, the current study also explored a possible explanation for the relationship between counterfactual thinking and FB by examining the roles of both working memory and inhibitory control. Recent reviews of the development of executive function suggest that key components of executive function develop on different trajectories (Carlson, 2005; Garon, Bryson, & Smith, 2008). This may influence the relationship between counterfactual thinking and FB. Working memory was assessed using backward digit span, counting and labeling, and finger tapping and labeling. Inhibitory control was assessed by tasks used by Carlson and colleagues (Carlson & Moses, 2001; Carlson et al., 2002): grass/snow, bear/dragon, and card sort. The following four hypotheses were tested. First, counterfactual thinking will predict FB performance. Second, working memory will account partially for the relationship between counterfactual thinking and FB. Third, inhibitory control will account partially for the relationship between counterfactual thinking and FB given that inhibitory control has been shown to predict counterfactual thinking more than working memory has (Beck et al., 2009). Fourth, inhibitory control will account for unique variance above and beyond that of working memory in the relationship between counterfactual thinking and FB.

Method

Participants

A total of 76 3-year-olds (n = 24, 10 girls and 14 boys, mean age = 41.21 months, range = 36–47), 4-year-olds (n = 27, eight girls and 19 boys, mean age = 52.81 months, range = 48–58), and 5-year-olds (n = 25, 14 girls and 11 boys, mean age = 63.56 months, range = 60–69) participated in the study. All participants were recruited from local preschool centers and through their parents who were enrolled in introductory psychology classes at Idaho State University. Children were primarily Caucasian and from middle-class homes from Pocatello, Idaho, and surrounding areas.

Procedure

Participants were tested individually in three 15- to 20-min sessions. The measures consisted of the Test for Auditory Comprehension of Language–III (TACL3; Carrow-Woolfolk, 1999), FB tasks, counterfactual thinking tasks, a working memory battery, and an inhibitory control battery. Parents completed a demographic survey. In the first session, children completed the language measure. In the second session, participants completed the FB and counterfactual items, which were counterbalanced to control for order effects. In the third session, they completed the working memory battery and the inhibitory control battery, which also were counterbalanced.

Measures

Language

The TACL3 (Carrow-Woolfolk, 1999) was used to assess language comprehension. This was included to control for the relationship between language and both FB performance (e.g., Astington & Jenkins, 1995; Milligan, Astington, & Dack, 2007) and counterfactual thinking (Guajardo et al., 2009). The TACL3 measures receptive language, including word comprehension, morphology, and sentence comprehension tasks. The TACL3 was administered according to standardized procedures. Each child received 1 point for every correct response (possible range = 0–120 points). The total raw score was used for all analyses.

False belief

FB was assessed using unexpected change, deception, and unexpected contents tasks. Characters used in the stories were the same sex as the child (indicated by a forward slash, e.g., Bruce/Pam), and the stories were acted out with props. Each child received credit for passing an FB task only if he or she answered *both* the corresponding control and test questions correctly. Across tasks, the child received a total FB score ranging from 0 to 7. Scores were standardized and summed for analyses, resulting in a range from 0 to 3.

Unexpected change. Following Wimmer and Perner (1983), the child was told about Max/Maxi, his/her mother, and the chocolate. Max/Maxi and his/her mother return from the store and put the chocolate away in the blue cupboard. Max/Maxi leaves the room, and his mom moves the chocolate to the red cupboard. Next, the child was asked three control questions. The child was asked about the actual and previous locations of the chocolate and whether the character saw the chocolate being moved. If the child answered incorrectly, he or she was told to listen to the story again and then was asked the question again. The story was repeated only one time. Next, the test question was administered: "Where will Max/Maxi first look for the chocolate?" Each child received a score of 1 for the correct response, "the blue cupboard," and a score of 0 for the incorrect response, "the red cupboard." If the child answered the control questions incorrectly, however, he or she received a score of 0 regardless of whether the response to the test question was correct or incorrect.

Deception. In this task, the child was confronted with one character tricking another character (Wimmer & Perner, 1983). The child was told, "Here is Bruce/Pam. He/She took the candy out of the candy box and put it in the crayon box so that his/her brother/sister would not find it. Bruce/Pam did not want his/her brother/sister to eat the candy before Bruce/Pam got any. When Bruce/Pam's brother/sister comes into the room, he/she asks Bruce/Pam where the candy is. Bruce/Pam decides to tell his/her brother/sister something completely wrong so his/her brother/sister will not find the candy." Next, the child was asked, "Where will Bruce/Pam say the candy is?" Each child received 1 point for a correct response of "in the candy box" and 0 points for an incorrect response of "in the crayon box." Memory/control questions were also asked: "Did Bruce/Pam move the candy" and "Where is the candy really?" The child received 0 points for the task, regardless of whether he or she passed the test questions, if the control questions were answered incorrectly.

Active deception. In this task, the child was actively involved in deceiving Bill/Sarah by moving candy into a different drawer. The child was told, "Bill/Sarah knows that there is candy in the green cabinet. Bill/Sarah has to leave the room for a minute. Let's play a trick on Bill/Sarah. Let's move the candy to the orange cabinet." The child then was asked who moved the candy. Next, the child answered questions about where the candy used to be, where it is now, and whether Bill/Sarah saw it being moved. If the child responded incorrectly to these control questions, he or she was asked to listen to the story again and the control questions were readministered. Failure to answer the control questions correctly resulted in a score of 0 regardless of whether the test questions were answered correctly. Finally, the test question was asked: "Where will Bill/Sarah first look for the candy?" A correct response of the green cabinet earned the child a score of 1, and an incorrect response of the orange cabinet earned him or her a score of 0.

Unexpected contents. The first unexpected contents task assessed the child's understanding of his or her own representational change (Lewis & Osborne, 1990). The child was shown a Band-Aid box and asked, "What do you think is inside the box?" Next, the experimenter showed the real contents: "Let's look inside. Look, there is a toy car in here. Imagine that, a Band-Aid box with a toy car inside." Next, the test question was asked: "What did you think was in the box?" If the child responded correctly, he or she received a score of 2. If the child responded incorrectly, he or she was asked, "What did you think was in the box before I opened it?" The child received 1 point for a correct response. If both questions were answered incorrectly, the child received a score of 0. Finally, a memory question was asked to make sure that the child still remembered the actual contents of the box. If the child answered incorrectly, he or she received a score of 0 for the task regardless of whether the test questions were answered correctly.

The second unexpected contents task was an FB explanation task (Bartsch & Wellman, 1989). The same props from the first unexpected contents task were used along with the addition of a similar unmarked box that contained Band-Aids. The child was shown the contents of both boxes to ensure that he or she still remembered the contents of the Band-Aid box (i.e., a toy car) from the first task. The child was introduced to John/Sue and told, "Look, here is John/Sue. John/Sue has a cut and he/she wants a Band-Aid." A doll was placed by the Band-Aid box. Next, the child was asked why John/Sue is looking in that box. Again, the child received a prompt if he/she answered this question incorrectly: "What does John/Sue think?" If the child answered the first test question with reference to John/Sue's thoughts, he or she received a score of 2. If the child answered the prompt test question with reference to the character's thoughts, he or she received a score of 1. If the child answered both questions incorrectly, he or she received a score of 0. Finally, the child was asked the control question: "Where are the Band-Aids really?" If the child answered this control question incorrectly, he or she received a score of 0.

Counterfactual thinking

The counterfactual thinking tasks included both antecedent and consequent tasks. There were a total of eight hypothetical scenarios referring to oneself and others. Each child received a score of 1 for a correct response, with the total score ranging from 0 to 4 for antecedent counterfactuals and 0 to 4 for consequent counterfactuals. A correct response was one that was judged to be logical and related to the scenario (e.g., "Wipe my feet first" in response to "What could you have done so that the kitchen floor would not have gotten dirty?"). Other unrelated and illogical statements received a score of 0. As with the FB tasks, counterfactual thinking scores were standardized and summed for analyses, leading to a range from 0 to 3.

Antecedent counterfactuals. For the antecedent counterfactual reasoning tasks, each child was asked to imagine himself or herself in a situation (see Guajardo & Turley-Ames, 2004). For example, the child was told, "Imagine that you are playing outside in the muddy yard. You are thirsty, so you go inside to the kitchen to get a drink of juice. You walk through the mud, you step over the doormat, and you keep your shoes on. Because your shoes are muddy, you get dirt all over the floor." The child was then asked the test question: "What could you have done so that the kitchen floor would not have gotten dirty?" The child was further prompted, "Can you think of anything else?" to allow as many responses as possible, consistent with the methodology of Guajardo and Turley-Ames (2004). For the purposes of the current study, children received 1 point for providing a plausible counterfactual statement. There were a total of four antecedent tasks, and so scores ranged from 0 to 4. The scenarios were designed to encourage both upward (i.e., better than reality) and downward (i.e., worse than reality) counterfactual thinking (see Guajardo & Turley-Ames, 2004), although type of counterfactual was not analyzed in the current study.

Consequent counterfactuals. The consequent counterfactual thinking tasks were presented in a manner similar to the antecedent tasks. The stories required the child, when presented with an antecedent, to reason about likely consequences (Riggs et al., 1998). The sex of the character in the story matched that of the participant, as with the FB tasks. For example, the child was told, "Pam/Peter is in her/his house, but Pam/Peter isn't feeling very well. So, she/he goes to bed. The phone rings, and the man from the post office asks Pam/Peter to come and help put out a fire. Pam/Peter gets out of bed and goes to the post office." Next, the child was asked, "If there had not been a fire, where would Pam/Peter be?" There were a total of four consequent tasks. As explained earlier, the child received 1 point for a correct response (range = 0–4). Each situation required the child to reason about the whereabouts of a character or an object in a situation (i.e., other-focused).

Working memory

The working memory tasks tapped both storage and active portions of immediate memory. The child earned a score based on how many digits he or she could correctly say in reverse on the backward digit span. The other two measures were scored as correct or incorrect (1 or 0, respectively). Scores were standardized and then summed for a total working memory score with a range from 0 to 3 for each child.

Backward digit span. The child was asked to repeat a list of digits backward (Davis & Pratt, 1995). The experimenter first provided an example: "If I say '1, 2', you say '2, 1'." The child was given a practice trial repeating two digits (e.g., experimenter says "2, 3" and child says "3, 2"). Each child was corrected if he or she completed the practice trial incorrectly. The test trials began after the practice trial. The digit span increased by one digit for each successful response. If the child completed a two-digit trial correctly (e.g., "1, 2" and "2, 1"), he or she was given a three-digit trial (e.g., "1, 2, 3" and "3, 2, 1"). The child's digit span score corresponded with the highest successfully completed digit set. For example, a score of 3 was given for success with the three-digit trial but failure with the four-digit trial.

Counting and labeling. This is a dual performance task (Gordon & Olson, 1998). The experimenter presented three toy objects to the child and demonstrated the steps. The experimenter first named each object ("crayon, sock, cat") and then gave each object a number ("one, two, three"). Finally, the experimenter counted and named each object in turn out loud (i.e., "one is crayon, two is sock, three is cat"). The child was asked to repeat the steps demonstrated. The child was corrected after the first step (labeling) and after the second step (counting) but not after the third step (counting and labeling). The child was given two opportunities to complete the task correctly. Successful completion of the trial occurred when the child correctly counted and labeled each object out loud (e.g., "one is car, two is dog, three is cup"). The child received a score of 2 for completing the trial correctly on the first attempt, a score of 1 for completing the trial correctly on the second attempt, or a score of 0 for completing the trial incorrectly (range = 0–2).

Finger tapping and labeling. For this dual-performance task, the child was asked to label toy objects while continuously tapping the table with his or her finger (see Gordon & Olson, 1998). The experimenter demonstrated the task, and then the child was given a practice trial in which he or she was reminded to keep tapping his or her finger during labeling (e.g., ∗tap∗ pencil, ∗tap∗ girl, ∗tap∗ cow, ∗tap∗). The child completed two trials. Performance was scored as either 0 for incorrect or 1 for correct. To receive a score of 1, the child needed to perform the task correctly on one of two attempts.[1]

Inhibitory control

This multitask battery was used previously by Carlson and colleagues (Carlson & Moses, 2001; Carlson et al., 2002). The scoring is explained for each task. The total inhibitory control score ranged from 0 to 34 for each child. The score for each child on each measure was standardized and summed for a range from 0 to 3.

Grass/snow. This is a Stroop-like task in which the child paired color with the opposite associate (Carlson & Moses, 2001; Passler, Isaac, & Hynd, 1985). The child was first presented with two cards. The experimenter labeled a green card as "green" and a white card as "white." The child was instructed to point to the green card when asked for "snow" and to point to the white card when asked for "grass." The experimenter demonstrated the task. Next, the child completed two practice trials that were followed by 16 test trials. There were eight green cards and eight white cards. The cards were presented in the same order for all participants. Each correct response by the child received a score of 1 point, and each incorrect response received a score of 0 points (total score range = 0–16).

Bear/dragon. This task (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996; Reed, Pien, & Rothbart, 1984; see also Carlson & Moses, 2001) is an imitation suppression task. The task requires a child to obey some commands and to suppress responses to other commands, similar to the game *Simon Says.* Two puppets were introduced: Nice Bear and Naughty Dragon. The child was instructed to obey and not obey these puppets, respectively. The experimenter explained, "We like Nice Bear, so we will do what he/she says. We don't like Naughty Dragon, so we won't listen to him/her." The child completed a practice trial set in which Nice Bear said, "Touch your nose," and then Naughty Dragon said, "Touch your toes." A total of 10 test trials (five bear trials/five dragon trials, alternating) were administered. Each child was reminded of the rules after five trials, as suggested by previous research (see, e.g., Carlson & Moses, 2001). Scores were computed on Naughty Dragon trials only because the purpose of the task was to determine the child's ability to suppress a response. Consistent with previous research (see Carlson & Moses, 2001), scores ranged from 0 to 3 for each trial (0 = *full move/imitation,* 1 = *partial move/imitation,* 2 = *wrong move,* 3 = *no move* [correct response]). The total score for this measure ranged from 0 to 15.

Card sort. The card sort was based on procedures developed by Frye and colleagues (1995) and Carlson and Moses (2001). Each child was instructed to sort cards based on one criterion (i.e., shape) and then based on a second criterion (i.e., color). This switching required the child to inhibit the old sorting rule in favor of the new sorting rule. There were five trials with shape as the criterion and five trials with color as the criterion. Each child was shown two containers: one with a picture of a red rabbit and the other with a picture of a blue boat. The experimenter explained that rabbits go into the rabbit container and boats go into the boat container. Next, the experimenter demonstrated with a blue rabbit card and a red boat card. The child sorted based on the shape criterion first for five trials. Next, the experimenter explained that the child was now to sort by color. Two of the color trials were compatible with the old rule (i.e., red rabbit and blue boat). That is, a child sorting the cards by either the old rule (i.e., sort by shape) or the new rule (i.e., sort by color) could make a correct response. Three of the trials were incompatible with the previous shape rule. Only the incompatible trials were scored.

[1] The experimenters did not objectively measure the *rate* of finger tapping as a part of the data examined. However, they did notice a decreased tapping rate during labeling.

The child received a score of 1 for placing the card in the right container and a score of 0 for placing the card in the wrong container. The total score for this measure ranged from 0 to 3.

Results

Descriptive statistics

The means and standard deviations for FB, counterfactual thinking, working memory, and inhibitory control batteries are reported in Table 1. To ensure internal consistency, a reliability analysis was computed for each battery. Coefficient alphas ranged from .56 to .85. FB tasks were high on internal consistency (Cronbach's α = .85). However, the three other task batteries demonstrated modest internal consistency (αs = .56–.63; see, e.g., Graham & Lilly, 1984). These data are also reported in Table 1. Table 2 provides the descriptive statistics by age.

Table 1
Descriptive statistics for age, language, FB, counterfactual thinking, working memory, and inhibitory control measures (N = 76).

Variable	*M*	SD	Minimum	Maximum	α
Age (months)	52.68	9.46	36	69	
Language (TACL3)	61.57	21.35	20	111	
FB measures	2.39	2.47	0	7	.85
1	0.34	0.48	0	1	
2	0.38	0.49	0	1	
3	0.68	0.87	0	2	
4	0.59	0.80	0	2	
5	0.39	0.49	0	1	
Counterfactual measures	4.91	1.69	1	8	.56
A1	0.86	0.93	0	3	
A2	0.59	0.88	0	3	
A3	1.43	1.02	0	5	
A4	0.82	0.93	0	5	
C1	0.72	0.45	0	1	
C2	0.59	0.50	0	1	
C3	0.71	0.46	0	1	
C4	0.54	0.50	0	1	
Working memory measures	2.07	1.89	0	7	.56
BDS	0.72	1.14	0	4	
FTL	0.67	0.47	0	1	
CL	0.67	0.87	0	1	
Inhibitory control measures	23.67	9.86	0	34	.63
Grass/Snow	11.33	5.46	0	16	
Bear/Dragon	10.46	5.85	0	15	
Card sort	1.84	1.32	0	3	

Note: FB, false belief; A, antecedent; C, consequent; BDS, backward digit span; FTL, finger tapping and labeling; CL, counting and labeling.

Table 2
Means (and standard deviations) for language, FB, counterfactual thinking, working memory, and inhibitory control totals by age.

	Age		
	3-years olds (n = 24)	4-years olds (n = 27)	5-years olds (n = 25)
Language (TACL3)	46.33 (16.55)	60.85 (18.75)	76.96 (17.38)
FB measures	0.25 (0.53)	2.78 (2.61)	4.04 (1.97)
Counterfactual measures	3.88 (1.68)	5.04 (1.53)	5.76 (1.36)
Working memory measures	0.75 (0.85)	1.70 (1.61)	3.72 (1.70)
Inhibitory control measures	13.79 (7.68)	26.07 (8.29)	30.56 (4.39)

Note: standard deviations are in parentheses. FB, false belief.

Simple correlation statistics for FB, counterfactual thinking, working memory, and inhibitory control are presented in Table 3. All variables of interest were significantly intercorrelated. Boys and girls performed similarly on all tasks; thus, sex was not considered in further analyses. As expected, age and language comprehension were related to FB performance, counterfactual thinking, working memory, and inhibitory control. FB performance and counterfactual thinking scores were correlated as well.

Mediational analyses

We predicted that working memory and inhibitory control would mediate the relationship between counterfactual thinking and FB. To test this hypothesis, Baron and Kenny's (1986) four-step method was used to assess mediation. Thus, a series of regression equations were conducted. Following Baron and Kenny's steps, the criterion variable and the predictor were entered into the equation to show that the initial variable was correlated with the outcome variable. Next, to confirm that the initial variable was correlated with the mediator, the mediator was entered as the criterion variable and the initial variable was entered as the predictor in a second equation. After that, the outcome variable was entered with both the mediator variable and the initial variable as predictors. This analysis indicated whether the mediator affected the outcome variable while controlling for the possible overlap with the initial variable. To examine whether the mediator completely or partially mediated the relationship, the final equation was assessed to determine whether the effect of the initial variable on the outcome variable was reduced.

Working memory mediator

These analyses confirmed that counterfactual thinking was a significant predictor of both FB performance ($\beta = .848$, $p < .001$) and working memory ($\beta = .51$, $p = .002$). Children who had higher counterfactual reasoning scores performed better on FB tasks and on the working memory measures. Moreover, working memory was a significant positive predictor of FB ($\beta = .40$, $p < .001$). In the final equation, FB was predicted using both working memory and counterfactual thinking entered simultaneously. The association between counterfactual thinking and FB was reduced, but it remained significant after controlling for working memory ($\beta = .64$, $p < .001$). This equation suggests that working memory explains, in part, why changes in counterfactual reasoning skills effect changes in FB performance. A Sobel test confirmed a significant difference from zero ($z = 2.57$, $p < .01$). Fig. 1, demonstrating the nature of the partial mediation, is included for reference and to further clarify the results.

Inhibitory control mediator

Analyses confirmed that counterfactual thinking was a significant predictor of both FB performance ($\beta = .848$, $p < .001$) and inhibitory control ($\beta = .64$, $p < .001$). Children who had better counterfactual thinking skills had higher FB scores. In addition, children who had higher counterfactual thinking scores had better inhibitory control. Moreover, inhibitory control was a significant predictor of FB ($\beta = .574$, $p < .001$). Those who were better at inhibitory control performed better on FB tasks. Finally, FB was predicted using both inhibitory control and counterfactual thinking entered simultaneously. The association between counterfactual thinking and FB was reduced, but it remained significant after

Table 3
Correlation matrix for all task batteries.

Variable	1	2	3	4	5	6	7
1. Age	–						
2. Language	.64*	–					
3. Sex	−.10	−.09	–				
4. FB total	.65*	.74*	−.03	–			
5. Counterfactual total	.49*	.49*	.11	.58*	–		
6. Working memory total	.67*	.63*	−.15	.53*	.39*	–	
7. Inhibitory control total	.67*	.73*	.03	.68*	.48*	.51*	–

Note: simple correlation coefficients are shown. FB, false belief.
* $p < .001$.

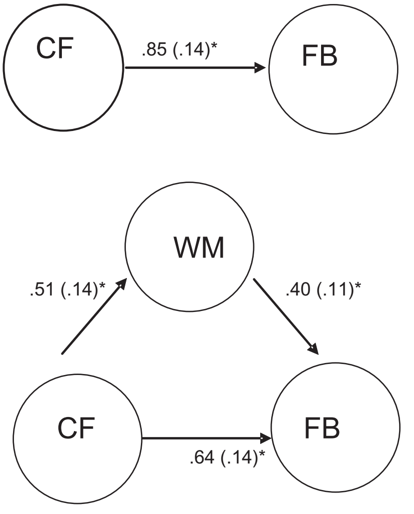

Fig. 1. Model for working memory as a mediator between counterfactual thinking and false belief. CF, counterfactual thinking; FB, false belief; WM, working memory. $^{*}p < .05$.

controlling for inhibitory control ($\beta = .480$, $p < .001$). A Sobel test confirmed a significant difference from zero ($z = 3.61$, $p < .001$). Fig. 2, demonstrating the nature of the partial mediation, is included for reference and to further clarify the results.

Hierarchical regression analyses

Hierarchical regression equations were used to determine whether inhibitory control or working memory accounts for more variance in the relationship between FB and counterfactual thinking. It was predicted that inhibitory control would account for unique variance above and beyond working

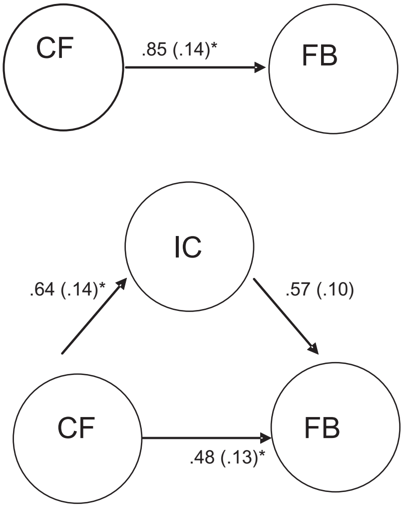

Fig. 2. Model for inhibitory control as a mediator between counterfactual thinking and false belief. CF, counterfactual thinking; FB, false belief; IC, inhibitory control. $^{*}p < .05$.

memory in the relationship between counterfactual thinking and FB. In the first block, FB was entered as the dependent variable and age and language were included as predictors. Age and language were significant predictors (βs = .077 and .064), ts(73) = 3.045 and 5.723, $p < .01$ and $p < .001$, respectively. Age and language together accounted for 60% of variance in FB performance, $F(2, 73) = 54.45$, $p < .001$. Counterfactual thinking was entered in the second block and was a significant predictor of FB performance (β = .341), $t(72) = 2.759$, $p < .01$. Counterfactual thinking accounted for nearly 4% of unique variance in FB performance. In the third block, working memory was entered but failed to account for significant variance in FB performance over and above age, language, and counterfactual thinking (β = −.024), $t(71) = -.213$, *ns*. Finally, inhibitory control was entered, and it also failed to account for additional variance. Thus, there was no evidence that working memory and inhibitory control were significant predictors of FB beyond those of age, language, and counterfactual thinking (see Table 4). When we reversed the block orders of inhibitory control and working memory in the second hierarchical regression analysis, working memory again failed to account for significant variance in FB performance above and beyond age, language, counterfactual thinking, and inhibitory control. Thus, there was no evidence that inhibitory control was a significant predictor of FB beyond those of age, language, counterfactual thinking, and working memory (see Table 4).

Developmental trajectory mediation

The partial mediation effects found with working memory and inhibitory control may be due to age differences and developmental trajectories for executive functions (Carlson, 2005; Garon et al., 2008). Thus, we examined further the mediational relationships by separating the data by age group (i.e., 3-, 4-, and 5-year-olds) and using the same four-step method suggested by Baron and Kenny (1986) described previously. This analysis was exploratory, and the researchers recognized the limitations posed by small sample sizes.

Mediation analyses with inhibitory control as the mediator could not be completed for each age group; counterfactual thinking did not predict inhibitory control at 3, 4, or 5 year of age (β = .265, p = .228, β = .391, p = .136, or β = .166, p = .304, respectively). However, it is also important to note that the regression analyses confirmed that counterfactual thinking was a significant predictor of FB performance for 3-year-olds (β = .166, p = .009), 4-year-olds (β = .906, p = .004), and 5-year-olds (β = .589, p = .04). As suggested by other analyses, children who had higher counterfactual reasoning scores performed better on FB tasks.

Table 4
Hierarchical regression analysis predicting FB performance (N = 76).

Block	β	t Value	R^2 change	sr^2
Block 1			.60	
Age	.077	3.045*		.051
Language	.064	5.723*		.180
Block 2			.038	
Counterfactual total	.341	2.759*		.038
Block 3			.013	
Inhibitory control total	.200	1.654		.013
Block 4			.000	
Working memory total	−.009	−0.079		.000
Block 1			.60	
Age	.077	3.045*		.051
Language	.064	5.723*		.180
Block 2			.038	
Counterfactual total	.341	2.759*		.038
Block 3			.000	
Working memory total	−.024	−0.213		.000
Block 4			.013	
Inhibitory control total	.199	1.630		.013

Note: upper panel: multiple R = .807, R^2 = .651, Se = 1.512. Lower panel: multiple R = .807, R^2 = .651, Se = 1.512. FB, false belief.
* $p < .001$.

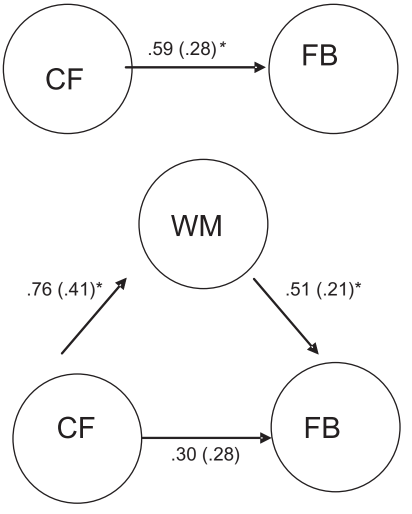

Fig. 3. Model for working memory as a mediator between counterfactual thinking and false belief for 5-years olds. CF, counterfactual thinking; FB, false belief; WM, working memory. $^{*}p < .05$.

Working memory was considered as a mediator for 3-, 4-, and 5-year-olds' data separately. In these analyses, counterfactual thinking was a significant predictor of working memory performance, but only for 5-year-olds ($\beta = .570$, $p < .05$). For 3- and 4-year-olds, counterfactual thinking scores did not significantly predict working memory ($\beta = -.050$, *ns,* and $\beta = .147$, *ns,* respectively). Thus, mediational analyses could not be completed for 3- and 4-year-olds. Working memory also predicted FB scores for 5-year-olds ($\beta = .510$, $p < .05$). In the final regression equation, 5-year-olds' FB performance was predicted using both working memory and counterfactual thinking entered simultaneously. The association between counterfactual thinking and FB ($\beta = .303$, *ns*) was reduced to nonsignificant levels after controlling for working memory. Thus, counterfactual thinking scores predicted FB performance indirectly through working memory for 5-year-olds. Fig. 3, demonstrating the nature of the mediation, is included for reference and to further clarify the results.

Discussion

A primary purpose of the current study was to extend research exploring the relationship between counterfactual thinking and FB performance using the methods of Guajardo and Turley-Ames (2004). In particular, the current study assessed executive functions, specifically working memory and inhibitory control, as possible mediators. This allowed examination of the theoretical explanations of the relationship between counterfactual thinking and FB.

Counterfactual thinking and false belief

The current study confirmed that counterfactual thinking is related to FB. By demonstrating a strong correlation between performance on the counterfactual thinking and FB tasks, even after controlling for age and language, the data replicated the findings of previous researchers (e.g., German & Nichols, 2003; Guajardo & Turley-Ames, 2004; Guajardo et al., 2009; Riggs et al., 1998). Thus, the development of counterfactual thinking may enhance a child's ability to consider alternatives and suppress irrelevant information, which in turn affects FB development. Correlational analyses, however, cannot determine the true direction of effect. The data also suggest the importance of executive function for the relationship between these variables.

Working memory as a mediator

Recent studies have found that executive function is a significant predictor of FB performance (e.g., Carlson & Moses, 2001; Carlson et al., 2002; Davis & Pratt, 1995; Gordon & Olson, 1998). More specifically, increases in resource capacity (Davis & Pratt, 1995; German & Nichols, 2003; Gordon & Olson, 1998) and conflict inhibitory control (Carlson & Moses, 2001; Carlson et al., 2002; Kochanska et al., 1996) are related to FB. In the current study, working memory was associated with both counterfactual thinking and FB, consistent with previous research (e.g., Carlson & Moses, 2001; Carlson et al., 2002; Davis & Pratt, 1995; Goldinger et al., 2003; Gordon & Olson, 1998; Turley-Ames & Whitfield, 2000).

The second hypothesis, which predicted that working memory would partially mediate the relationship between counterfactual thinking and FB, was supported. Working memory increases or becomes more efficient during early childhood, which may affect other aspects of cognitive development (Gathercole et al., 2004). The current study supports these suppositions with partial mediation findings. Fig. 1 shows that children who pass FB tasks have better working memory skills than those who do not. This fact supports suggestions made by Carlson and colleagues (Carlson & Moses, 2001; Carlson et al., 2002), German and Nichols (2003), and Guajardo and Turley-Ames (2004) that executive function could be important in the development of FB understanding (see also Frye et al., 1995; Gordon & Olson, 1998; Leslie & Roth, 1993), thereby signifying that when children are able to use their resources effectively, they are better able to navigate the social world around them.

Inhibitory control as a mediator

Inhibitory control also partially accounted for the relationship between counterfactual thinking and FB. Inhibitory control significantly correlated with both counterfactual thinking and FB. Furthermore, after controlling for inhibitory control, the relationship between counterfactual thinking and FB was reduced. From this, inhibitory control also appears to be an important contributor to the relationship between counterfactual thinking and FB, suggesting that when a child is able to inhibit effectively, either by maturation or development of learning strategies, he or she may be better able to navigate within the social world. Hughes (1998) found that 4-year-olds' inhibitory control ability predicted their ToM performance 1 year later, but not the other way around. Russell, Saltmarsh, and Hill (1999) found that executive factors, such as inhibitory control, may be the reason why children with autism fail FB and modified false photograph tasks. Children had difficulty inhibiting their current true belief while generating a response referring to another's belief. Russell and colleagues (Hill & Russell, 2002; Russell & Hill, 2001) also noted that a lack of cognitive flexibility may be why autistic individuals have difficulty with ToM tasks, further suggesting that executive control is essential for developing ToM understanding.

Inhibitory control has been found to account for more variance in FB (Carlson et al., 2002) and in counterfactual thinking (Beck et al., 2009) than does working memory. Based on these findings and on the supposition that executive functions, such as inhibitory control, would account for the relationship between counterfactual thinking and FB, the final hypothesis was that inhibitory control would account for unique variance above and beyond that of working memory in the relationship between counterfactual thinking and FB. This hypothesis was not supported. Neither inhibitory control nor working memory accounted for unique variance after controlling for age, language, counterfactual thinking, and working memory or inhibitory control, respectively. Also, counterfactual thinking continued to predict FB performance after controlling for working memory and inhibitory control (separately). This suggests that there is something in addition to executive function accounting for the relationship between counterfactual thinking and FB. Possibilities may include abilities related to language or general status such as age.

Developmental trajectory of working memory as a mediator

Due to differences in FB performance of 3-, 4-, and 5-year-olds and the partial mediation findings, further exploration was conducted for each age group separately. These analyses revealed that executive function may become more important to the relationship between counterfactual thinking and FB as a child gets older. Specifically, counterfactual thinking was a significant predictor of working memory, and working memory predicted FB scores for 5-year-olds only. We recognize that conclusions are limited by a small sample size, yet they indicate an interesting direction for future study. The findings suggest that working memory becomes a mediator of the relationship between counterfactual reasoning and FB later during the preschool years. Interestingly, this was not the case for inhibitory control. Counterfactual thinking did not predict inhibitory control when the age groups were examined separately. This was somewhat surprising. It is possible that, as with working memory, inhibitory control becomes more important with age. It is also possible, however, that inhibitory control is important in the facilitation of FB performance prior to 5 years of age and the limited participant numbers failed to capture this in our analyses. The different findings for working memory and inhibitory control may be consistent with previous work suggesting that working memory and inhibitory control develop at the same time, yet independently, and become increasingly integrated with age (Roncadin, Pascual-Leone, Rich, & Dennis, 2007).

In sum, the first three hypotheses were supported. The fourth hypothesis, that inhibitory control would predict variance above and beyond that of working memory in the relationship between counterfactual thinking and FB, was not supported, but other factors may explain this finding. The results generally indicate that development of the ability to hold information in mind and the ability to suppress intrusive thoughts and behaviors is important for the relationship between counterfactual thinking and FB performance.

Theoretical implications

As mentioned in the Introduction, a number of ideas have been proposed to explain the relationship between counterfactual thinking and FB, including "aboutness" (Perner, 2000), modified derivation (Peterson & Riggs, 1999), and general limitations in counterfactual reasoning (Riggs et al., 1998). Yet, each theory has been found to be insufficient. Although the current research cannot conclusively arbitrate between the possible theoretical explanations, it does add to our understanding of the role that executive function might play in explaining the relationship between counterfactual thinking and FB. For instance, the current study found that working memory explained, in part, why changes in counterfactual thinking skills effect changes in FB performance. More specifically, 5-year-olds' counterfactual thinking scores predicted FB performance indirectly through working memory. Furthermore, inhibitory control partially explained the relationship between counterfactual thinking and FB for all ages combined. These findings lend support to an executive function account.

The underlying components of executive function, namely working memory and inhibitory control, may first facilitate the development of focused attention and attentional shifting. Several studies have found significant enhancement in attention between 3 and 5 years of age (e.g., Akshoomoff, 2002; see review in Garon et al., 1998). Thus, the development of attention may precede the development of other aspects of executive function. A child must first be able to attend to a task before he or she can allocate resources appropriately. However, the development of selective attention, separate from attention shifting, can create difficulty for some tasks. For example, a child who is high on focused attention yet low on attentional shifting may perform well on inhibition tasks (e.g., bear/dragon, grass/snow) but not so well on cognitive flexibility tasks (e.g., card sort). In the current study, 3-year-olds performed better on the bear/dragon task ($n = 7$, incorrect on all inconsistent trials) and grass/snow task ($n = 5$, score of 0) than on the card sort task ($n = 11$, incorrect on all inconsistent trials). These kinds of observations may further illuminate which aspects of executive function are truly important in the relationship between counterfactual thinking and FB and at what point in development. Future work should examine the role of additional aspects of executive function in accounting for associations between counterfactual thinking and FB.

Astington and Jenkins (1995) argued that the development of social cognitive understanding might have different pathways. Previous research by Dunn (1995) found that understanding beliefs and emotions were not correlated prior to 40 months of age. Thus, Astington and Gopnik (1991) argued that a child might come to understand representation and belief through various means. They found that pretend play and language develop at around 2 years of age and that reality and imaginary distinctions develop at around 3 years of age. At 4 years of age, a child is able to understand changes in his or her own beliefs, actively deceive others, and recognize differences between appearance and reality. Carlson (2005) reviewed nine studies and also found that working memory and inhibitory control performance increased from 2 to 5 years of age. Specifically, Carlson found that 51% of young 3-year-olds passed the bear/dragon task, whereas older 3-year-olds passed 76% of the time. Thus, it is possible that developmental trajectories may be similar for both counterfactual thinking and FB. Future research will need to examine the importance of different developmental trajectories for executive functions and the relationship between counterfactual thinking and FB.

Conclusions

The current study adds to our understanding of the relationship between counterfactual reasoning and ToM. In particular, counterfactual thinking significantly predicted FB performance after controlling for age and language. Furthermore, working memory and inhibitory control each partially accounted for the relationship between counterfactual thinking and FB performance. Interestingly, working memory was more important at 5 years of age than earlier in development. Thus, early improvements in executive function, particularly working memory and inhibitory control, underlie developmental changes in the relationship between early counterfactual reasoning and ToM understanding.

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