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Abstract

The hypothesis that inhibitory control – an aspect of executive functioning – is related to children's suggestibility was tested. Five- to 7-year-olds ($N = 125$) participated in a staged event, were suggestively interviewed, and were later given a recognition test. Conflict and interference measures of inhibitory control were taken and compared to children's ability to identify details from the target event and reject details from non-target sources (i.e., false suggestions, details from prior events). Children with higher than average verbal retroactive inhibition skills were more resistant to suggestions than children with poor inhibitory control. Collectively, age and retroactive inhibition skills accounted for 17% of the variance in suggestibility scores, with each making independent contributions. Three other measures of inhibition did not, however, correlate significantly with resistance to suggestion. The findings are discussed in relation to a multi-component view of eyewitness memory emphasizing links between inhibitory control, suggestibility, and source monitoring.

The relation between inhibitory control and children's eyewitness memory

Research on children's memory for events that they have witnessed provides a consistent story about children's abilities. For example, children's age and the strength of their memory traces have repeatedly been shown to relate to children's accuracy in both non-suggestive and suggestive paradigms (Brainerd, Reyna, Howe, & Kingma, 1990; Bruck & Ceci, 1997; Goodman, Bottoms, Schwartz-Kenney, & Rudy, 1991; Holliday, Douglas, & Hayes, 1999; Peterson, 1999; Lamb, Sternberg, & Esplin, 2000). These factors have been used to inform police and others who interview child witnesses or victims in criminal cases about children's competencies. Despite this consensus, there still remain several critical omissions in our understanding of child eyewitnesses. First, the majority of studies document a high degree of individual variance in measures of children's memories, even among children matched for chronological age. In other words, age only partly explains performance (e.g., Poole & Lindsay, 2001). Second, although forgetting plays an important part, even children who remember their experiences make significant errors (e.g., Powell & Roberts, 2002). Many contemporary developmental theories posit that children's ability to regulate their memories and cognitive processes and translate them into actions (i.e., their executive functioning) underlies many aspects of children's cognitive performance (Harnishfeger, 1995). In the current study, we examine the usefulness of an executive functioning account of eyewitness memory when children have been exposed to multiple sources of information, such as, in misinformation or repeated-event paradigms.

Eyewitness Memory

Children can provide accurate and sometimes detailed accounts of their experiences (e.g., Burgwyn-Bailes, Baker-Ward, Gordon, & Ornstein, 2001; Fivush & Shukat, 1995; Peterson &

Whalen, 2001). Sometimes, however, children are exposed to other events or sources of information that in some way relate to and can contaminate memories of a target event (for reviews, see Roberts, 2002; Roberts & Powell, 2001). For example, children may listen to a story about a similar event (e.g., Poole & Lindsay, 2001), hear inaccurate descriptions of the same or similar events (e.g., Leichtman & Ceci, 1995; Roberts, Lamb, & Sternberg, 1999), watch a similar event on television (e.g., Roberts & Blades, 1999; Thierry, Spence, & Memon, 2001), be suggestively interviewed about an event (e.g., Ceci, Huffman, Smith, & Loftus, 1994; Imhoff & Baker-Ward, 1999; Marche, 1999), experience other similar events (Connolly & Lindsay, 2001; Powell & Roberts, 2002), or dream about an event. For clarity, we hereafter refer to the original event as the target event, and related events as non-target events or sources. A typical finding in the above studies is that suggestibility, or the tendency to change one's report of the target event in line with non-target sources such as those listed above, is negatively correlated with age (Bruck & Ceci, 1997), though reverse trends have been observed (e.g., Brainerd, Reyna, & Forrest, 2002), as well as age invariance in suggestibility (e.g., Howe, 1991). Even when there are linear age trends, considerable variation often exists within an age group (e.g., Roberts & Blades, 1999; Quas, Qin, Schaaf, & Goodman, 1997), suggesting that individual differences are also critical to the accuracy of children's eyewitness memory.

Although social factors such as the perceived credibility or authority of the interviewer (e.g., Ceci, Ross, & Toglia, 1987) or a socially-supportive atmosphere (e.g., Carter, Bottoms, & Levine, 1996) can lead to developmental differences in the accuracy of children's reports, much research has investigated the effects of memory-based processes. Constructionist accounts posit that the non-target information replaces or blends with the original information so that the target information is no longer available (e.g., Loftus, 1995; Welch-Ross, Diecidue, & Miller, 1997;

Welch-Ross, 2000). Trace theories claim that the non-target information is more accessible than the target information, for example, if the non-target information was more recently presented or was presented multiple times (e.g., Holliday, Douglas, & Hayes, 1999; Marche, 1999; Pezdek & Roe, 1995). Suggestibility is predicted by the above accounts at times when the false, non-target information is represented by a stronger memory trace and is thus more likely to be retrieved than is the original memory trace. For example, Holliday et al. presented 5- and 9-year-olds with a picture story (either once or thrice) and a misleading narrative about the story (either once or thrice). Suggestibility was greatest under circumstances when the post-event trace was strong (i.e., the narrative was presented thrice) and the original trace was weak (i.e., the story was presented once).

Despite the robust finding that memory is related to children's suggestibility, in many studies, children have been able to report information from *both* target and non-target events indicating that both sources of information were encoded and retrieved (e.g., Ackil & Zaragoza, 1995; Marche & Howe, 1995; Roberts & Blades, 1999; Powell & Roberts, 2002; Thierry et al., 2001). For example, in a study on the effects of three prior experiences on memory of a target event, Powell et al. (1999) found that 75% of the information recalled by 5- to 6-year-olds took place in one of the four occurrences. However, children were highly confused about which details took place in the target event and which were from the three prior occurrences. Hence, some researchers have suggested that children's errors reflect source confusions, that is, children mistakenly attribute the source of non-target information to the target event (e.g., Ackil & Zaragoza, 1995; Lindsay & Johnson, 1987). A source-monitoring account is supported by evidence that errors are reduced when children are encouraged to pay attention to the origins of their memories (Lindsay, in press; Poole & Lindsay, 2001; Thierry et al., 2001). The ability to

accurately monitor sources undergoes significant developments from ages 3 through 8, and this is also the age at which children are typically most suggestible (see Bruck & Ceci, 1997).

According to the source-monitoring framework, accurately determining the origin of information requires strategic and reflective abilities (Johnson et al., 1993). Such processes may require an awareness of the goal of a task, an identification of the best strategies to achieve the goal, and the regulation of attention so that resources are directed towards processes that optimally achieve the goal and away from non-optimal processes (Ruffman, Rustin, Garnham, & Parkin, 2001). Children younger than 3- or 4-years do not appear to have reflective awareness of where they learned information (Robinson, 2000), but considerable improvements in explicit reflection of source-monitoring judgments occur between ages 4 and 8 (e.g., Poole & Lindsay, 2001; Roberts & Blades, 1999). Given the executive nature of source-monitoring decisions, we reasoned that 5- to 7-year-olds' ability to accurately remember a target event after they have been exposed to non-target sources should be related to their executive-functioning skills. For the reasons listed below, we focus specifically in the current investigation on the role of inhibitory control, an important aspect of executive functioning.

Inhibitory Control

Recall that several studies have demonstrated that children can retrieve both target and non-target information (e.g., Powell & Roberts, 2002). It seems plausible, then, that accurately reporting target information involves the inhibition of irrelevant (i.e., non-target) information so that attention is focused on the target information. This could be achieved by preventing irrelevant information from entering working memory, by suppressing non-target information that has already entered working memory, or by restraining dominant response candidates so that alternatives can be considered (Hasher, Chung, May, & Foong, 2002). Second, one may need to

inhibit processes, such as familiarity-based reasoning, that typically result in inaccurate

responses (Ruffman et al., 2001). For example, when memory of an event is tested, children can

mistakenly claim information they actually learned from a video occurred in the event simply

because the information seemed familiar. A more strategic analysis of memory of the

remembered material may have led to the identification of the true source, in this case the video,

which would then allow a rejection of the material as originating from the event.

The ability to ignore task-irrelevant information, processes, and automatic or prepotent

responses is considered to be part of an executive skill known as *inhibitory control*.

Contemporary developmental theories consider inhibition as a central construct (e.g., Brainerd &

Reyna, 1990; Dempster, 1993; Harnishfeger & Bjorklund, 1993; see Harnishfeger, 1995, for a

review) and its role has been demonstrated in a variety of contexts such as theory-of-mind

development (e.g., Carlson, Moses, & Nix, 1998; Frye, Zelazo, & Palfie, 1995; Moore, Jarrold,

Russell, Lumb, Sapp, & MacCallum, 1995), free recall (e.g., Brainerd, Reyna, & Howe, 1990),

math skills (Bull & Scerif, 2001), and delay of gratification (e.g., Mischel, Shoda, & Rodriguez,

1989).

Developmentally, marked improvements in inhibitory control usually occur between ages

4 and 7 and this is believed to be dependent on frontal lobe development, the area of the brain

that is implicated in executive control (e.g., Dempster, 1993; Passler, Isaac, & Hynd, 1985).

During this period, children show improvements in their ability to attend to stimuli in the face of

salient alternatives, to delay an immediate reward to get a larger reward at a later time, and to

suppress an otherwise automatic response. As discussed above, it is also after this period that

children typically become less susceptible to suggestibility (see Bruck & Ceci, 1997) and are

more able to monitor the sources of their memories at a level closer to that of adults (Roberts,

2002). Both functionally and ontogenetically, then, inhibitory processes are implicated in eyewitness memory.

The co-occurrence of frontal lobe, inhibitory control, and source-monitoring developments does not prove their interactive role in the accuracy of eyewitness memory. However, there are theoretical links that support this position. For example, a recent investigation found a positive correlation between source monitoring and inhibitory control (Ruffman et al., 2001). Six- to 10-year-olds watched a video and listened to an audiotape about a dog. Inhibitory control, measured with a Stroop-like task where children had to count the number of digits in an array despite the conflicting number of the digit (e.g., say '3' in response to the array '2 2 2'), was positively related to children's ability to accurately identify the source of items that were in the video. Ruffman et al. argued that the task involved the inhibition of familiarity-based retrieval processes. As noted above, source monitoring requires strategic and reflective processes (Johnson et al., 1993) and so we investigated whether inhibitory control may be one of these processes.

Contemporary models of false-memory editing (i.e., the ability to reject postevent misinformation) focus on automatic memory processes (e.g., the "recollection-rejection model", Brainerd & Reyna, 2002) or strategic metacognitive monitoring processes (e.g., the "strategic-suppression model", Koriat & Goldsmith, 1996). However, many researchers acknowledge that both automatic and intentional processes can contribute to successful false-memory editing, and may be most successful when both kinds of processes are simultaneously engaged (e.g., Brainerd & Reyna, 2002; Holliday, Reyna, & Hayes, 2002; Johnson, Hashtroudi, & Lindsay, 1993). Both kinds of models provide a theoretical home for the role of inhibitory control in resistance to suggestion.

Harnishfeger (1995) distinguished between unintentional and intentional inhibition. Unintentional inhibition involves the suppression of activated irrelevant items to allow processing of relevant items and occurs without any conscious awareness; intentional inhibition occurs when there is a deliberate attempt to suppress stimuli such as in directed-forgetting paradigms. We extrapolate that unintentional inhibition can also involve suppressing sub-optimal processing in favour of processing that better suits the demands of the task, without conscious awareness. Memory-based models that focus on item-level suppression, such as recollection-rejection (Brainerd & Reyna, 2002), allow the possibility that false memories can be edited with the aid of unintentional inhibition. According to the recollection-rejection model, a false suggestion (e.g., *Coke*) that is nevertheless consistent with the gist of the item that was initially experienced (e.g., *7-Up*) can activate the representation of the original item. A verbatim mismatch occurs because the verbatim details of the original and suggested items differ, for example, the smell and colour may be different. Hence, the *inhibition* of gist acceptance processing allows a verbatim mismatch, thus providing release from reliance on a familiarity-driven judgment that would lead a child to mistakenly accept the gist-consistent *Coke* as an original item.

Regarding metacognitive models, inhibitory control can be consciously pursued when instructed to actively monitor one's memories on a group-level basis (as in the strategic-suppression model, Koriat & Goldsmith, 1996). In general, participants are explicitly instructed at the beginning of the test to reject suggested information. As outlined by Koriat and Goldsmith, greater rejection of non-target items occurs because participants are more motivated to do so, and/or because they are more effectively monitoring their memories (e.g., assessing source, setting stricter criteria for acceptance, Johnson et al., 1993). It is possible that both automatic and

strategic processes are involved in both item- and group-level suppression and, as inhibition comprises several processes that vary in automaticity, the relation that we have proposed between inhibitory control and suggestibility is feasible for either account of false-memory editing.

The Current Investigation

Ruffman et al.'s (2001) results suggest that inhibitory control may be important in tasks that require the sources of memories to be identified. Given that children sometimes remember both target and non-target information (e.g., Powell & Roberts, 2002), it is plausible that success on a test of memory for a target event involves inhibiting task-irrelevant information from non-target sources and/or inefficient processes (e.g., familiarity or gist-acceptance) so that target information can be accurately identified. We tested whether this assertion is true by examining the relationship between inhibitory control skills and memory for a target event after exposure to non-target sources. The non-target sources comprised false suggestions and other experienced events that were similar to the target event.

We were able to collect numerous individual difference measures from a large sample of 5- to 7-year-old children who had participated in studies on the effects of repeated experience on children's suggestibility. Children participated in an event, were suggestively interviewed, and were later given a memory test about the event (Roberts & Powell, 2003). Immediately after the memory test, a battery of four inhibitory control tests was administered and it is these novel, individual differences data that we report in the current study. The inhibitory control scores were compared to the suggestibility data from the memory test, thus providing a test of the proposed relationship between inhibitory control and suggestibility.

We specifically expected that inhibitory control would be negatively correlated with suggestibility. We hypothesized that the ability to inhibit memories of previously experienced non-target details and to avoid familiarity-based processing would result in the dominant activation and processing of target details in working memory, thus leading to increased acceptance of target information (saying 'yes' when the target item was probed) and increased rejection of non-target information (saying 'no' when the non-target or suggested item was probed). This task implicitly requires source monitoring because children were specifically asked about the target event after exposure to non-target sources.

<div style="text-align:center">Method</div>

Participants

Data were provided by 125 children (61 girls) from five schools in the Melbourne metropolitan area whose parents had given informed consent. The mean age was 5 years, 9 months ($SD = 3.76$ months) and ranged from 5 years, 0 months to 7 years, 5 months. Children had initially been randomly assigned to one of eight Experience (single event, repeated event) x Suggestive Interview Delay x Memory Interview Delay cells. Specifically, children took part in the staged event once or four times, were suggestively interviewed three days or three weeks later, and were given a memory test the day after or three weeks after the suggestive interview. As the effects of experience and delay are not the focus of the present study, the scores from children in each cell were standardized to provide sufficient statistical power for an analysis of individual differences.

Materials

As is customary (e.g., Carlson & Moses, 2001; Passler et al., 1985), multiple tests of inhibitory control were administered. Specifically, we used two conflict tasks (a Stroop-like

day/night task and a tapping conflict task) and two verbal inhibition tasks (a verbal retroactive

inhibition [RI] task and a verbal proactive inhibition [PI] task). All four tasks are commonly used

in the literature (e.g., Carlson & Moses, 2001) and were chosen because success occurs at

different times for these tasks over the age range selected in the present study (Passler et al.,

1985). For the day/night task, two cards were created that were identical to the images used by

Gerstadt, Hong, and Diamond (1994). The cards measured 5.4 x 4 inches (approximately 13.5cm

x 10cm). For the tapping task, the child and experimenter each had a pencil that they used to tap

the table. The two interference tasks were exclusively verbal and included two practice trials

using words from Snodgrass and Vanderwart's (1980) normed set. The words for the test trials

were taken from the age-normed materials of the Wechsler Preschool and Primary Scale of

Intelligence-Revised (Wechsler, 1989), the Wechsler Intelligence Scale for Children (Wechsler,

1991), and the Peabody Picture Vocabulary Test-Revised (Dunn & Dunn, 1981). Two separate

word lists were created and administered to children alternately to control for item effects.

Procedure

   The suggestibility procedure.

   A trained research assistant (RA) administered the 30-minute activity to groups of 20-28

children aged 5 to 7 (though only children whose parents gave informed consent participated in

the suggestive and memory interviews). Each activity comprised 16 target details embedded in

several activities: physical exercise, listening to a story, doing a puzzle, getting a surprise, and

relaxing.

   An unfamiliar RA suggestively interviewed the children about the target event (the only

or final occurrence of the activities), by inaccurately describing half of the event details and

accurately describing the other eight details. For example, the interviewer could inaccurately say

"I heard there was a puzzle of a clown *driving a car with a flat tire*. Who put the puzzle together that day?" (inaccurate details in italics). Questions with inaccurate presuppositions such as these are known to effectively elicit suggestibility effects (e.g., Roberts et al., 1999) and, indeed, did so.

The same RA who carried out the previous session later interviewed the children about the 16 target details in the target event using two sets of yes/no questions; one question in each set probed the accurate version of the detail, the other probed the inaccurate version (e.g., for the above example, "Was there a puzzle of a clown juggling, when you wore the badge?" [true description], and "Was there a puzzle of a clown with a flat tire, when you wore the badge?" [false description]). This resulted in 32 questions in total (i.e., 16 question pairs, one pair for each target detail). Whether the accurate or suggested version of each detail was presented first was counterbalanced, as was the order of presentation of the two sets. Children were given a pre-test containing two questions comprising a correct 'yes' answer and a correct 'no' answer. All children correctly answered these questions and so no children were excluded. In the main test, children were to be excluded if they consistently said 'yes' to every question or 'no' to every question, though none did and thus none were excluded.[1] Children were considered correct if they accurately answered *both* 'no' to the question about the suggested detail and 'yes' to the question about the target detail, thus, there was therefore a maximum score of 16.

Inhibitory control assessment.

Immediately after the memory interview, the children were given the inhibition tasks. We followed the procedure for the *day/night task* reported in Gerstadt et al. (1994). For the first trial, the child was shown the picture of the sun and asked to say the word "night". The child was then instructed to say "night" every time s/he saw the sun card. The picture of the moon was then

presented and the child was asked to say "day". The child was then instructed to say "day" every time s/he saw the moon card. If the child did not say the specified word, the experimenter prompted the child by saying "What do you say to this card?" without actually mentioning the word. If the child still did not respond, the interviewer reminded the child of the procedure, and repeated the practice trials. Once the child was correct on two consecutive trials, the main testing began. The child was shown the sun and moon cards in random order, one at a time, for a total of fourteen presentations (seven sun and seven moon presentations). The card was held up for a second or until the child said "day" or "night". The only constraint was that no more than two presentations of the same card could be presented in succession.

The procedure for the *tapping task* followed that of Luria (1973). The experimenter tapped the table once with a pencil and instructed the child to tap the table twice. The experimenter waited while the child did this. The experimenter then tapped the table twice and informed the child to tap just once, again pausing until the child tapped. The practices continued until the child was correct on two consecutive trials, at which point the main testing began. For the next 14 trials, the experimenter tapped the table either once or twice, in random order with the constraint that the same number was not tapped more than twice in a row. The number of times that the child tapped the table for each turn was recorded.

A practice session preceded both of the *verbal inhibition tests*. First, the child listened to the experimenter say one set of three words (e.g., cat-table-clock) and was asked to repeat the words. The child then listened to the experimenter say another set of three words (e.g., hat-snake-ladder) and was asked to repeat this second set. The words were spoken at one-second intervals. For the RI task, the child was then asked to repeat the first set of words again (i.e., cat-table-clock) to see whether words from the second set interfered with recall of words from the

first set; for the PI task, the child was required to repeat the second set (i.e., hat-snake-ladder) to see whether words from the first set interfered with recall of the second. The child was given four such practice trials and if the child accurately repeated at least one of the three words from the specified set on two consecutive trials, main testing began. Main testing comprised five trials and the number of words the child repeated from the target sets (maximum of 15 for each test) was recorded.

To prevent perseverance effects on the verbal inhibition tasks, these tasks were alternated with the conflict tasks. Eight orders were created (e.g., day/night, PI, tapping, RI; PI, tapping, RI, day/night, etc.). As each child was tested, the experimenter rotated through these orders to prevent order effects contaminating the results.

Coding

Children's responses to the 16 pairs of yes/no questions were scored as correct if they answered 'yes' to the accurate description of the item *and* 'no' to the inaccurate description. Hence, these scores (out of 16) effectively show resistance to suggestion and will hereafter be referred to as the "resistance scores". A *high* score reflects *low* suggestibility. Standardized resistance scores were used in all subsequent analyses.

Responses to the four inhibitory control tests were coded as correct or incorrect (as outlined above). Thus, there was a maximum correct score of 14 for the day/night and tapping tests; 15, for the RI and PI tests. *High* scores reflect *high* levels of inhibitory control.

<div align="center">Results</div>

Descriptive Analyses

Descriptive data for the four inhibition tests are displayed in Table 1. While scores on the day/night, tapping, and PI task were above the median scale value, almost half of the sample

(43%) failed the RI pre-test. Only children who passed the pre-tests were included in the following analyses. Bivariate correlations were computed between the four inhibitory control tests and age (in months). Scores on the RI test were positively correlated with scores on all three other tests (RI and day/night: $r = .23$, $p = .05$; RI and tapping: $r = .24$, $p < .05$; RI and PI: $r = .43$, $p < .001$). Age was positively related to PI scores only ($r = .24$, $p < .02$).

We predicted that inhibitory control would be positively related to the resistance scores. There was a positive correlation between the RI scores and standardized resistance scores ($r = .34$, $p < .01$), and the correlation remained when age was controlled ($r = .31$, $p < .01$). None of the other inhibition scores correlated significantly with the resistance scores (rs = .05, .12, -.01, for the day/night, tapping, and PI scores, respectively).

Inferential Analyses

To further explore the relation between the RI and resistance scores, children were classified as high or low inhibitors. The score corresponding to the 50th percentile of the RI test was used as the cutoff, thus, children scoring below the 50th percentile score were classified as "low inhibitors" ($N = 38$, $M = 0.71$, $SD = .80$), and those scoring at or above the 50th percentile score were classified as "high inhibitors" ($N = 33$, $M = 5.52$, $SD = 2.12$).

It was predicted that children with low inhibition scores would be less resistant to suggestions than children with high inhibition scores. The resistance scores were entered into a 2 (RI group: low, high) *t*-test. As expected, High inhibitors (Raw scores: $M = 11.58$ out of 16, $SD = 3.10$; Standardized scores: $M = 0.39$, $SD = 0.82$) were less suggestible than Low inhibitors ($M = 9.45$, $SD = 3.86$; ; $M_z = -0.26$, $SD_z = 1.14$), $t(69) = -2.74$, $p < .01$ (see Figure 1). A 2 (RI group: low, high) analysis of covariance was carried out on the resistance scores, and showed that the main effect described above remained when age was controlled, $F(1, 68) = 5.42$, $p = .02$.

To cross-validate these results, we classified the children who provided RI scores as suggestible or not, to test the hypothesis that suggestible children have less well developed inhibitory control skills than children who can resist suggestions. A 50th percentile split on the standardized resistance scores was used to create a "high resistance" group ($N = 36$, $M = 0.85$, $SD = 0.36$) and a "low resistance" group ($N = 35$, $M = -0.79$, $SD = 0.85$). We then compared the RI scores of children in the low and high resistance groups using an independent samples t-test. As predicted, children in the high-resistance group had higher RI scores ($M = 3.83$ out of 15, $SD = 3.07$) than those in the low-resistance group ($M = 2.03$, $SD = 2.34$), $t(69) = -2.78$, $p < .01$ (see Figure 2). The main effect of group was also found when the RI scores were analyzed with a 2 (Resistance group: low, high) ANCOVA controlling for age in months, $F(1, 68) = 6.37$, $p = .01$.

Finally, regression analyses were carried out to estimate the relative contribution of inhibitory control and age to resistance to suggestibility. Two models were tested. Model 1 regressed inhibitory control (i.e., RI) onto the resistance scores, and Model 2 regressed age in months and RI score onto the resistance scores. Both models were significantly different from zero: Model 1, $R = .34$, $F(1, 70) = 9.05$, $p < .01$; Model 2, $R = .41$, $F(2, 70) = 6.96$, $p < .01$. Model 1, with RI as the only predictor, accounted for 12% of the variance in resistance scores; Model 2, with age in months and RI as the predictors, accounted for 17%, F change $(1, 68) = 4.42$, $p < .05$. The standardized coefficients from Model 2 showed that RI made a greater contribution ($\beta = .30$, $t = 2.71$, $p < .01$) than did age ($\beta = .24$, $t = 2.10$, $p < .04$). Children with low RI scores were more suggestible than those with high RI scores, consistent with the results reported above, and younger children were more suggestible than older children. Thus, the regression analyses showed that age and RI collectively predicted a modest amount of the

variance in the resistance scores, and RI made an independent contribution above and beyond age.[2]

Discussion

This research was undertaken to understand the processes connected with children's difficulty in providing information about a specific, target event after exposure to false suggestions and related events. Although research has shown that memory undoubtedly plays a large part, there are times when children fail to identify the target information even when memory for target and non-target information is intact. One possibility in these cases is that children's errors stem from source-monitoring deficiencies whereby memories from a non-target source intrude into reports of the target source. Source monitoring requires strategic and reflective processing according to the source-monitoring framework (Johnson et al., 1993), yet it is not clear what these processes might be with regards to children's performance. In the current study, we investigated whether executive functioning – specifically, inhibitory control – was related to children's ability to discriminate between target and non-target event information in an eyewitness paradigm. We reasoned that children who could inhibit task-irrelevant information (in this case, memories of non-target events) and processes (e.g., familiarity-based reasoning) and thus focus more on task-relevant information (i.e., memories of the target event) would be better able to identify target event information and reject non-target information in a recognition test. We found clear and consistent evidence that inhibitory control, as measured by the verbal retroactive inhibition task, was positively related to resistance to suggestibility: Children with greater than average levels of inhibitory control were less suggestible than children with low inhibitory control. Further, although age expectedly also contributed to children's suggestibility with younger children being more suggestible than older children, retroactive inhibition skills

made a substantial, unique contribution to the variance in the suggestibility scores (i.e.,

independently accounting for 12%).

Although retroactive inhibition was strongly and consistently related to suggestibility, the

relation between inhibition and suggestibility was not observed when inhibition was measured by

the two conflict tasks (day/night, tapping) and the proactive inhibition task. Table 1 shows that

scores on these three tasks were above average and quite high. Hence, it could be that ceiling

effects on these measures reduced the chances of finding a significant relationship.[3] Performance

on inhibitory control tasks in general shows dramatic development between the ages of 6 and 8,

with peak performance on many tasks (such as the nonverbal conflict and verbal proactive

inhibition tasks used in the current study) evident around age 8. Adult levels of verbal retroactive

inhibition are not achieved, however, until about age 12 (Passler et al., 1985). Thus,

suggestibility may have been more sensitive to variations in verbal retroactive interference than

other measures of inhibitory control in this sample of 5- to 7-year-olds. That is, the children in

our sample (whose average age was almost 6 years) could control their responses in the conflict

and verbal proactive interference tasks, but showed great individual variation in their ability to

resist interference retroactively, in line with Passler et al.'s (1985) findings. An obvious

extension of this work, then, is to replicate the study with a younger sample of children who

might show greater variance in inhibition and who are undergoing significant developments in

executive control and other skills that are localized in the frontal lobe, such as source monitoring

(Dempster, 1993).

The finding that inhibitory control (as measured by the retroactive inhibition test) was

related to accuracy after exposure to misinformation and highly similar experiences does not

oppose other theoretical explanations of eyewitness accuracy (e.g., trace theory, Marche, 1999;

understanding of conflicting mental representations, Welch-Ross et al., 1997). Rather, it is possible that inhibitory control is one of a set of processes necessary to accurately report target information. Recent discussions on eyewitness memory and suggestibility highlight its complex and multi-component nature and stress the importance of individual differences (e.g., Imhoff & Baker-Ward, 1999; Quas et al., 1997; Poole & Lindsay, 2001; Roebers & Schneider, 2001). Poole and Lindsay, for example, found that age, acquiescence, recall, and source monitoring all contributed independently to children's suggestibility.

As noted earlier, Ruffman et al. (2001) found that inhibitory control was related to source monitoring. As we used an implicit test of source monitoring (i.e., to recognize target and reject non-target information requires source monitoring), a logical extension of this and Ruffman et al.'s research is to examine the relation between inhibition and a direct measure of source monitoring in a suggestibility or repeated events paradigm. Theoretically, it would be especially interesting to examine relations between these skills and working memory, language, and an understanding of conflicting mental representations in situations requiring source discrimination given the reported co-variation of these skills (e.g., Astington & Jenkins, 1999; Carlson & Moses, 2001; Ruffman et al., 2001; Welch-Ross et al., 1997). Such investigations may illuminate what kinds of processes are needed to accurately report information from a specific, target event. The relationship may also contribute to an understanding of memory of traumatic events considering that some victims of crimes are motivated to actively inhibit painful memories (see Anderson & Green, 2001).

Although the hypothesized relationship between retroactive inhibitory control and suggestibility was observed, these novel results demand replication. Theoretically, the finding that inhibitory control uniquely contributed to suggestibility above and beyond age, generates

many interesting and testable hypotheses. The relation between inhibition and suggestibility in an eyewitness situation should be most important when the non-target source is more prepotent or dominant than the target source (e.g., when probed in a recognition test, at long delays, when the target details have been forgotten, when the suggestions are highly plausible) or when source confusions are highly likely (e.g., when there is no explicit demand to monitor source, when sources are highly similar, etc.). Inhibitory control, in contrast, should not relate to accurately reporting memories of details that were never inaccurately described because there would be less need to inhibit memories of non-target details, and target details can be identified on the basis of familiarity alone (cf. Ruffman et al.'s [2001] finding that inhibitory control was not related to correct recognition). Further, how might inhibitory control interact with social processes involved in suggestibility? It may be that suggestions from a plausible or knowledgeable interviewer are harder to inhibit than suggestions from less credible sources. In the current study, the person who suggestively interviewed the children also carried out the subsequent memory interview (i.e., was knowledgeable). Children who possess a "theory of mind" (as the 5- to 7-year-old children in the current would have done) are more suggestible when interviewed by a knowledgeable interviewer than an ignorant interviewer (Welch-Ross, 1999). Thus, children with a theory of mind but who lack strong inhibitory skills may be more at risk than children without strong inhibitory skills to succumbing to the suggestions from knowledgeable interviewers. Further research can identify the exact relationships between these variables and clarify how cognitive and social mechanisms interact to produce suggestibility effects.

In sum, the main contribution of the reported results is that they a) provide an empirical demonstration of the relationship between individual differences in an aspect of executive functioning and eyewitness memory, a finding that motivates subsequent investigations to more

fully understand the nature of the relationship, and b) suggest how different cognitive processes and age may interact in complex ways. Further research is clearly needed, however, to fully understand the nature of the relationship beyond this exploratory work. The power of the findings is that they indicate one process that may be involved when children remember *both* target and non-target (e.g., suggested) information. The findings add to a multi-component, developmental view of the suggestibility process and indicate that, in future, it may be beneficial to focus on the relations between emerging cognitive skills localized in the frontal lobes (e.g., inhibitory control, source monitoring, working memory) that may be involved when children are required to report information from a target event. Increased understanding of the complexity of suggestibility mechanisms promotes a more sensitive assessment of child witness competencies, perhaps leading to the identification of predictors other than age.

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Footnotes

[1]Children did, however, err more often by saying 'yes' to both questions (29% of responses) than by saying 'no' to both questions (4% of responses).

[2]A regression analysis was carried out to see whether a model with age and all four measures of inhibitory control accounted for any more of the variance than did the model with just RI and age. The model with all five predictors was just significant, $R = .41$, $F(5, 63) = 2.38$, $p = .05$, but accounted for no more of the variance than did the model with just RI and age as predictors (i.e., both models accounted for 17% of the variance). Additionally, in the five-predictor model, Beta values were above .10 only for RI ($\beta = .25$, $t = 1.76$, $p = .08$, 2-tailed) and age ($\beta = .29$, $t = 2.31$, $p < .05$). Thus the model with RI scores and age provided the best fit for the data.

[3] Also, although all scores were significantly correlated with the RI score, the correlations were in the weak to modest range (i.e., rs between .20 and .40). This again points to a ceiling effect, especially on the conflict tasks that showed the weakest correlations with RI score. Perhaps the conflict and PI tasks did not produce enough range in scores to find stronger relationships between the variables.

Table 1

Descriptive data for the inhibition tests.

Statistic	Day/Night Test (out of 14)	Tapping Test (out of 14)	Proactive Inhibition Test (out of 15)	Retroactive Inhibition Test (out of 15)
Minimum score	0.00	0.00	0.00	0.00
Maximum score	14.00	14.00	15.00	12.00
Mean score	10.84	12.12	9.80	2.94
Standard Deviation	3.53	2.99	4.65	2.87
N passed pre-test	125	124	104	71
N failed pre-test	0	1	21	74

Table 2

Bivariate correlations between the inhibitory control tests, age, and resistance to suggestibility.

Test	Day/Night	Tapping	Proactive Inhibition	Retroactive Inhibition	Age (in months)
Tapping	-.035				
	N = 124				
Proactive Inhibition	.033	.089			
	N = 104	N = 103			
Retroactive Inhibition	.232*	.244*	.429***		
	N = 71	N = 71	N = 64		
Age (in months)	-.005	.003	.235**	.159	
	N = 125	N = 124	N = 104	N = 71	
Standardized	.054	.116	-.010	.340***	.117
Resistance Scores	N = 125	N = 124	N = 104	N = 71	N = 125

Notes.

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.02 level (2-tailed).

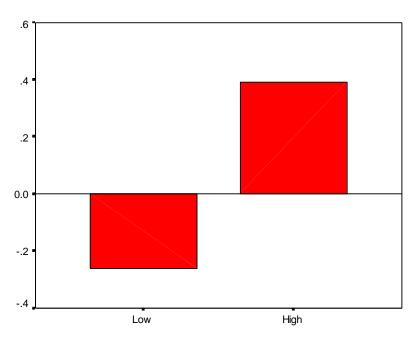*** Correlation is significant at the 0.01 level (2-tailed).
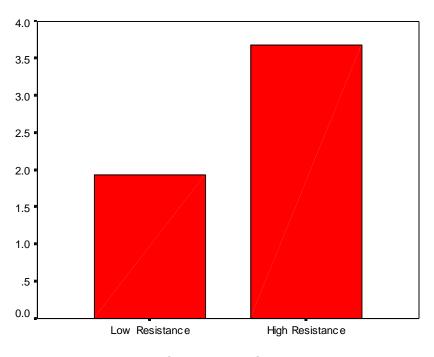
Figure Captions

Figure 1

Resistance to suggestibility as a function of inhibitory control level.

Figure 2

Inhibitory control scores as a function of resistance to suggestibility.

Retroactive Inhibition Level

Suggestibility Group