2003

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Recommended Citation

Steffen Wilson, Katherine Kipp, and Jennifer Daniels. "Task Demands and Age-Related Differences in Retrieval and Response Inhibition" British Journal of Developmental Psychology 21 (2003): 599-613.

British Journal of Developmental Psychology (2003), 21, 599–613

www.bps.org.uk

Task demands and age-related differences in retrieval and response inhibition

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This study investigates the role of task demands on children's ability to inhibit irrelevant information using a block-cued directed-forgetting task. Recall performance was compared in a block-cued directed-forgetting task in which task demands had been decreased by presenting blocks of semantically related words with that in which unrelated words were presented. Inhibition patterns of recall were found at a younger age in the task that contained the related words than in the task that contained the unrelated words. These results suggest that previous results charting the development of cognitive inhibition may not have been exclusively the product of the development of inhibition, but rather a product of both the difficulty of the task and the development of inhibition.

The development of cognitive inhibition

The limited mental resources model proposes that children and adults have limited mental capacity available for the execuation of cognitive processes and the storage of information (Bjorklund, 1985, 1987; Case, 1985, 1995, Case, Kurland, & Goldberg, 1982). Additionally, these models propose that improvements in cognition occur due to increases in the efficiency of the execution of cognitive operations and not to increases in limited mental capacity. Therefore, the improvements in cognitive performance seen with development is a function of increases in processing speed or efficiency which releases previously used mental capacity to be used for additional processing or for storage. (See Hitch and Towse (1995) for an alternative to the capacity-based view of cognitive processing.)

Several contemporary theories suggest the importance of inhibitory processes in

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explaining improvements in cognition seen with age across childhood (Bjorklund & Harnishfeger, 1990; Brainerd & Reyna, 1993; Dempster, 1993). One such theory is the cognitive inhibition theory. Cognitive inhibition refers to the processing that has been proposed to occur when information enters working memory, is deemed irrelevant and is then deactivated (Harnishfeger & Bjorklund, 1993; Hasher & Zacks, 1988). Specifically, it is proposed that with age children become increasingly able to eliminate irrelevant information from the information-processing stream. This process facilitates cognitive processing by allowing the individual to process only relevant information and not waste limited mental capacity processing irrelevant information (Harnishfeger & Bjorklund, 1993; Harnishfeger, 1995).

Research investigating the development of inhibition in a variety of tasks provides evidence that young children are poor inhibitors of irrelevant information and that the ability to inhibit irrelevant information improves across childhood and early adolescence. Inhibition develops over late childhood and early adolescence in dichotic listening tasks (Pearson & Lane, 1991), in visual selective-attention tasks (Pearson & Lane, 1990), and in text-processing tasks (Kipp, Pope, & Digby, 1998). Inhibition is not found until early adulthood in processing the interpretations of garden path passages (Lorsbach & Katz, 1998).

Several investigators propose that inhibitory mechanisms are a family of constructs, instead of a single cognitive process. Dempster (1993) argues that there are three domains of inhibitory processes. These are inhibition within motor tasks, inhibition within perceptual tasks, and inhibition within linguistic tasks. Harnishfeger (1995) suggests two methods of classifying inhibitory processes. First, she distinguishes between inhibition that falls within behavioural domains and inhibition that falls within cognitive domains (although a few forms of inhibition may contain both cognitive and behavioural components). Cognitive inhibition involves the suppression of cognitive contents or processes, while behavioural inhibition involves the suppression of a previously rewarded or prepotent behaviour. Secondly, she distinguishes between unintentional and intentional inhibitory processes. Unintentional inhibition is the unconscious suppression of automatically activated irrelevant information. An individual engages in intentional inhibition when he or she consciously decides that an item is irrelevant and then suppresses its activation.

The direct-forgetting task

One task that can be used to investigate the development of intentional inhibition is the block-cued directed-forgetting (DF) task. This task has a long and rich empirical history and it has been used to examine *retrieval inhibition* and *response inhibition* (see MacLeod (1998) and Wilson & Kipp (1998) for reviews of research that utilize this task with adult and child participants respectively). In a block-cued DF task, participants are initially instructed to remember all of the words from a list. Following the presentation of the first half of the word list, participants in a 'Forget' condition are instructed to forget the preceding words and to concentrate their memory efforts on the subsequent list of words. The second list half is then presented. Using this procedure, the first half of the word list (first block) becomes to-be-forgotten (TBF), and the second half of the word list (second block) becomes to-be-remembered (TBR). At recall, participants are instructed to recall *all* of the words available in memory (Forget-All DF task). Retrieval inhibition patterns of recall are found when more TBR than TBF words are recalled, but recognition performance is equal for both blocks of words. The *All* instruction is used because previous research suggests that participants do not withhold retrievable words when all words in memory are requested at recall (MacLeod, 1999). Therefore, lower TBF than TBR word recall when all words are requested supports the conclusion that the activation of the TBF words has been suppressed. Recognition of the TBF and TBR words is also tested because lower recall *and* lower recognition of the TBF words in comparison to the TBR words has been interpreted as indicative of selective encoding of the TBR information, and not of retrieval inhibition of the TBF words (Lehman, McKinley-Pace, Leonard, Thompson, & Johns, 2001). Therefore, it is necessary to confirm that the TBF words that were not recalled were indeed encoded equally as well as the TBR words through a recognition task before one concludes that the TBF information has been inhibited. As a control, some participants are also tested in a 'Remember' condition in which there is no instruction to forget embedded within the word list. At recall, participants are asked to recall all of the words available in memory.[1]

In addition to the *All* instruction, an instruction to recall *Only* the items the participant was asked to remember can also be used (Forget-Only DF task). Higher *first block recall* in the Forget-All DF task in comparison to *first block recall* in the Forget-Only DF task indicates that the participant is producing response inhibition patterns of recall. That is, they can withhold from overt recall TBF cued words that are available in memory.

Using the block-cued DF task, Harnishfeger and Pope (1996) investigated the development of retrieval and response inhibition in 7-, 9-, and 11-year-olds, and adults in two experiments. They found and replicated retrieval inhibition patterns of recall in 11-year-olds. Retrieval inhibition patterns of recall were initially found in 9-year-olds, but not replicated in the second study. It was concluded that retrieval inhibition patterns of recall were consistent by age 11. Response inhibition patterns of recall were not found until adulthood.

The retrieval inhibition mechanism is believed to operate by segregating the TBR and TBF words into blocks and then decreasing the activation of the words in the TBF cued block. This is believed to be the result of the re-setting of the learning process following the presentation of the forget cue (Bjork, 1989). That is, following the presentation of the forget cue, all mnemonic activities are devoted exclusively to the TBR cued words. As a result of this, the TBF and TBR cued block become segregated in memory. The TBF block then becomes deactivated as the TBR cued block is encoded. Consequently, only the TBR words are retrieved at recall (Bjork, 1989; Bjork & Bjork, 1996; Elmes, Adams, & Roediger, 1970; Epstein, 1969; Epstein, Massaro, & Wilder, 1972; Geiselman, Bjork, & Fishman, 1983; Wilson & Kipp, 1998). As mentioned above, the TBF words remain accessible in memory and can be retrieved with a recognition task (Block, 1971; Elmes *et al.*, 1970; Wilson & Kipp, 1998). (See Basden and Basden (1998) for a discussion of mechanisms other than retrieval inhibition that may produce retrieval inhibition patterns of recall.)

[1] *An alternative method called DF, is the item-by-item cued DF task. This task cues words as TBR or TBF as they are presented, and it does not appear to measure inhibitory processes (Basden, Basden, & Gargano, 1993). Therefore, item-by-item cued DF will not be investigated in this paper.*

Task demands and age-related differences in inhibitory processes

Many of the tasks used to investigate the development of inhibitory processes were originally developed for use with adults, not children. Because these tasks are relatively effortful, the mere execution of tasks presented in previous research may have depleted young children's mental capacity (Case, 1985, 1995; Case *et al.*, 1982), leaving little or no mental capacity available for the inhibitory components of the task. Therefore, the age-related changes in inhibitory processes reported previously would not only be a product of the development of inhibitory processes, but also a product of task demands. In support of this hypothesis, Kipp and Pope (1997) found that 8-year-old children produced inhibition patterns of performance in a picture-naming task that was designed to be minimally resource consuming. This is much younger than children typically inhibit within tasks that have been used to measure cognitive inhibition (cf. Kipp *et al.*, 1998; Lorsbach & Katz, 1998; Pearson & Lane, 1990, 1991).

Additional evidence for the demanding nature of the block-cued DF task comes from Harnishfeger and Pope (1996). Although they consistently found retrieval inhibition patterns of recall in 11-year-old children using the block-cued DF task, they also found low levels of overall recall in the Remember condition for both the children and adults. Low overall recall suggests that this was a difficult task (per cent recall in the Remember condition for each age was: adults 40%; 11-year-olds 30%; 9-year-olds 23%; 7-year-olds 15%). Task difficulty may have been obscuring young children's ability to produce retrieval and response inhibition patterns of recall.

Decreasing task demands

As mentioned above, in order to devote effectively all processing to the TBR items following the forget cue, which will in turn result in the deactivation of the TBF cued items, the TBR and TBF items must be differentiated into sets (Bjork, 1970; Bjork & Bjork, 1996; Block, 1971; Elmes *et al.*, 1970; Geiselman, 1975; Geiselman *et al.*, 1983; Goernert & Larson, 1994; Jongeward, Woodward, & Bjork, 1975). Although not stated explicitly in original accounts of the retrieval inhibition mechanism in the directed-forgetting task (cf. Bjork, 1989), it is speculated that differentiating the TBR and TBF words into blocks requires external source monitoring (Basden & Basden, 1998). This is the case because the designation of the block to which each word belongs is made by the experimenter during the presentation of the task, an agent external to the participant (Johnson, Hastroudi, & Lindsay, 1993; Roberts, 2000). Six-year-olds have been found to be as efficient as 9- and 17-year-olds at external source monitoring in tasks utilizing both verbal and behavioural stimuli (Foley & Johnson, 1985; Foley, Johnson, & Raye, 1983). This suggests that age differences in external source monitoring should not affect recall performance in the block-cued DF task. However, both children and adults are not as efficient at external source monitoring when the sources of information to-be-discriminated are very similar (Lindsay, Johnson, & Kwon, 1991, Expts 1 and 2). Based upon this logic, making the blocks of words in a block-cued DF task dissimilar should enhance children's ability to segregate the words into blocks and consequently increase the differentiation of the TBF and TBR words. This should lead to a more complete re-setting of the learning process following the forget cue and enhanced deactivation of the TBF cued words. Fewer mental resources should also be consumed by experimentally differentiating the words into blocks for the children, leaving more mental resources available for learning the TBR cued words and thereby increasing the inhibition of the TBF cued words.

Block differentiation can be facilitated by using semantically categorized TBR and TBF word blocks in a DF task. Blocks of categorized words are more dissimilar than blocks of unrelated words, as each block of categorized words can be classified under a specific category name. Categorized words are also recalled in categorized clusters or blocks, providing additional support that there should be more block differentiation in a categorized than in an unrelated DF task (Moley, Olson, Halwes, & Flavell, 1969; Sophian & Hagan, 1978; Westman & Westman, 1977). Categorized words are also easier to recall than unrelated words (Loftus & Loftus, 1974; Neely, 1976; Postman, 1972; Rundus, 1971), which should allow for an additional decrease in task demands when categorized words are presented. In sum, because categorized words are more dissimilar (facilitating external source monitoring), recalled in categorized blocks, and easier to recall, a block-cued DF task created from blocks of categorized words should be less resource demanding than a block-cued DF task created from unrelated words.

Current study

The purpose of the experiment reported here is to investigate the role of task demands in age-related differences in retrieval and response inhibition in the block-cued directed-forgetting task. This will be investigated using a block-cued DF task with children.

Task demands will be decreased by presenting block-cued Forget-All and Forget-Only DF tasks that contain blocks of words from the same semantic category. Performance in these tasks will be compared to block-cued Forget-All and Forget-Only DF tasks that contain blocks of unrelated words. If task demands interfere with retrieval inhibition, retrieval inhibition patterns of recall should be found at younger ages in a Forget-All DF task that consists of blocks of categorized words than in a Forget-All DF task that consists of blocks of unrelated words. If task demands interfere with response inhibition, response inhibition patterns of recall should be found in a comparison of first block recall in categorized Forget-All and Forget-Only DF tasks at a younger age than in the same comparison in unrelated tasks.

Method

Participants

The participants in this study were 32 children. Sixteen children were 6-years old (*M* age = 6.31 years, *SD* = .47, 10 females, 6 males; 14 White, 1 African American; 1 Asian American) and 16 children were 8 years old (*M* age = 8.73 years, *SD* = .46, 12 females, 4 males; 15 White, 1 African American). All of the children attended a university supported model laboratory school serving primarily middle to upper-middle class socio-economic groups.

Design and materials

This experiment utilized a mixed design. Half of the participants from each age level were assigned to the Categorized condition, and half were assigned to the Unrelated condition. Participants in both conditions participated in three DF tasks, with tasks being presented in separate testing sessions with a minimum interval of one week between sessions.

Six 20-item target word lists were used to assess inhibitory ability. Each list was split into 2 blocks of 10 high frequency common nouns. Word frequency ratings were taken from Thorndike and Lorge (1944). Three of the lists contained 2 blocks of 10 words that were members of the same semantic category taken from the Battig and Montague (1969) lists of categorized words (List 1: animals, clothing; List 2: fruits and vegetables, furniture; List 3: toys, parts of a house). The remaining three lists each contained 2 blocks of 10 unrelated words. Both the unrelated and categorized lists were created in such a way that words that were strong categorical associates were not included on the list (e.g. If *doctor* was on the list, *nurse* and *hospital* were not on the list. If *cat* was on the list, *dog* was not on the list). The words in both blocks in each list were matched for word frequency. In addition, the three categorized lists were matched for word frequency and the three unrelated lists were matched for word frequency. The average frequency rating was higher in the unrelated lists ($M = 75.9$) than in the categorized lists ($M = 49.7$). The three categorized and the three unrelated lists were counterbalanced across the three DF tasks to avoid effects due to list instead of instruction.

A forced-choice recognition test was presented following recall in each DF task to measure the encoding of TBF and TBR block words. Recognition for each of the six lists was tested with a list that contained the 20 target words presented in the DF task, plus 20 additional foil words matched with the appropriate target lists for word frequency (for a total of 20 word pairs). In the categorized condition, each categorized target word was matched with a foil word from the same category.

Procedure

In individual testing sessions, the participants were told that they would be presented a list of words to be remembered for later free recall. Participants were read 1 word every 5 seconds, and they were asked to repeat each word following its presentation. To ensure that the categorized nature of the list was recognized by the participants in the Categorized condition, prior to the presentation of each block of words, participants were told the category to which the block of words belonged. As a counterpart to this instruction, participants in the Unrelated condition were told that all of the words on the list to be presented were unrelated prior to the presentation of each block of words. Prior to recall in each DF task, the Matching Familiar Figures Task (Kagan, 1965) was presented to all participants for 30 seconds as a buffer clearing task. This task was presented to ensure that the words recalled were not residing in short-term memory.

Each participant in both the Categorized and Unrelated conditions first received the Remember DF Task. Following the presentation of the first block of words, participants in the Remember condition were told to continue to remember the words that had been read and also to remember the following words for later. The second block of words was then presented to the participants. At recall, participants were asked to recall all of the words that they could remember. At least a week later, participants in both conditions received the Forget-Only DF task in which the mid-list instruction was to forget the first block of words. At recall, participants were asked to recall *only* the words they had been told to remember. At least a week after receiving the Forget-Only DF task, all participants in both conditions received the Forget-All DF task in which the mid-list instruction was to forget the first block of words. At recall they were asked to recall *all* of the words they were presented, even the words they had been told to forget.

Following recall, a forced-choice recognition task was presented to participants to measure encoding of the TBR and TBF word blocks. Bjork and Bjork (1996) reported that a forced-choice recognition task functioned similarly to a standard yes–no recognition task in adult participants. Participants were told that they would be read pairs of words, that one word in each pair was on the list they just learned, and one word in the pair was not on the list they just learned. Participants were asked to say the word in each pair that was on the previously studied list.

The DF tasks were presented in the order outlined above to maintain the validity of the mid-list instructions. The Remember DF task was presented before the Forget DF tasks to ensure that participants would follow the remember mid-list instruction (this might not occur if the Remember condition followed a task in which the mid-list instruction was to forget the first block of words). The Forget-Only DF task was presented before the Forget-All DF task to maintain the validity of the mid-list forget cue in the Forget-All condition (this might not occur if the All instruction was presented prior to the Only instruction). These two restrictions produced the Remember, Forget-Only, Forget-All task presentation order. To further decrease the likelihood of task order effects, prior to word presentation, all children in the Forget-All DF task were told that they may receive the forget instruction or that they may receive the remember instruction and that it was important that they try to remember as many words as possible. These instructions were modelled after those presented in Bjork and Bjork (1996), and they have been found to eliminate task order effects in adult participants.

Results

The analyses reported below adopt a. 05 level of significance, and all *t* tests are two-tailed. For each comparison, eta squared (η^2) or partial eta squared is reported as an estimation of the effect size. Eta squared values of .01, .06, and .15, represent small, medium, and large effect sizes, respectively (Green, Salkind, & Akey, 2000).

Remember condition

A 2 (Condition: Categorized, Unrelated) × 2 (Age: 6, 8) × 2 (Block: 1, 2) analysis of variance was conducted on recall in the Remember task (means and stardard deviations presented in Table 1). A main effect of Condition was found with more words being recalled in the Categorized (M = 3.82) than in the Unrelated condition (M = 2.82), F (1, 28) = 5.45, p <.05, *partial* η^2 = .16. This is consistent with previous research which has found that categorized words are easier to recall than unrelated words (Loftus & Loftus, 1974; Neely, 1976; Postman, 1972; Rundus, 1971). The main effect of Age approached significance with marginally more words being recalled by the 8-year-olds (M = 3.75) than by the 6-year-olds (M = 2.88), F(1, 28) = 4.17, p = .05, *partial* η^2 = .13. No other main effects or interactions were found (*partial* $\eta s^2 \leq .07$).

Retrieval inhibition

To investigate the effects of task demands on the age at which children's performance followed patterns of retrieval inhibition, a 2 (Condition: Categorized, Unrelated) × 2

Table 1. Mean recall as a function of task, condition, age and block

	Task		
	Remember	Forget-All	Forget-Only
Categorized condition			
Six-year-olds			
Block 1	2.87 (1.95)	1.25 (1.48)	0.88 (1.24)
Block 2	3.25 (1.28)	3.63 (1.06)	3.63 (1.40)
Eight-year-olds			
Block 1	5.00 (1.30)	2.75 (0.46)	1.00 (1.85)
Block 2	4.12 (2.41)	4.25 (1.58)	5.00 (2.20)
Unrelated condition			
Six-year-olds			
Block 1	2.75 (1.83)	1.62 (1.06)	1.63 (1.30)
Block 2	2.62 (2.07)	2.50 (1.19)	2.25 (1.58)
Eight-year-olds			
Block 1	3.12 (1.36)	0.88 (0.64)	0.38 (1.06)
Block 2	2.75 (1.83)	3.75 (2.19)	3.00 (2.00)

Note. Standard deviations are shown in parentheses. Maximum possible recall in each cell = 10.

(Age: 6, 8) × 2 (Block: 1, 2) analysis of variance was conducted on recall in the Forget-All DF task (means and standard deviations presented in Table 1). A main effect of Block was found with fewer words being recalled from the first block (M = 1.63) than from the second block (M = 3.53), F (1, 28) = 36.33, p <.05, *partial* η^2 = .57. A main effect of Condition was found with more words being recalled in the Categorized condition (M = 2.97) than in the Unrelated (M = 2.19) condition, F (1, 28) = 5.72, p <.05, *partial* η^2 = .17. The main effect of Age approached significance with marginally more words being recalled by the 8-year-olds (M = 2.91) than the 6-year-olds (M = 2.25), F (1, 28) = 4.04, p = .05, *partial* η^2 = .13. The Condition × Age × Block interaction was the analysis of interest and it was significant, F (1,28) = 5.17, p <.05, *partial* η^2 = .16. Planned comparisons of this interaction revealed that in the Categorized condition, children of both ages produced significantly lower first block recall than second block recall, ts (7) ≥ 2.37, p <.05, ηs^2 ≥.45. In the Unrelated condition, planned comparisons revealed no significant difference in the 6-year-olds' first and second block recall in the Forget-All DF task, t (7) = 1.38, p>.05, η^2 = .21. However, the 8-year-olds recalled significantly fewer first than second block words in the unrelated Forget-All DF task, t (7) = 4.54, p <.05, η^2 = .75. No other interactions were found (*partial* ηs^2 ≤.05). These results suggest that retrieval inhibition patterns of recall were produced by six years of age in the categorized DF task, but not until 8 years of age in the unrelated DF task. Although the effect size estimation indicated a large effect in the 6-year-olds in the Unrelated conditions, the combination of significant differences in first and second block recall and very large effect size estimations in both age groups in the Categorized condition and in the 8-year-olds in the Unrelated condition suggest that these groups are outperforming the 6-year-olds in the Unrelated condition.

Response inhibition

To investigate the effects of task demands on the age at which response inhibition is produced, a 2 (Condition: Categorized, Unrelated) × 2 (Age: 6, 8) × 2 (Task: Forget-Only, Forget-All) analysis of variance was conducted on *first-block recall* (means and standard deviations presented in Table 1). The main effect of Task approached significance with marginally more of the first block words in the Forget-All DF task ($M = 1.63$) being recalled than the first block words in the Forget-Only DF task ($M = .97$), $F(1, 28) = 3.81$, $p = .06$, *partial* $\eta^2 = .12$. The Condition × Age interaction was also significant, $F(1, 28) = 12.39$, $p<.05$, *partial* $\eta^2 = .22$. This interaction was driven by low first block recall by the 8-year-olds in both tasks in the Unrelated condition. The Condition × Age × Task interaction was the analysis of interest and it was not significant, $F(1, 28) = .42$, $p >.05$, *partial* $\eta^2 = .01$. Because differences in recall were predicted *a priori*, planned comparisons of this interaction were conducted. In the Categorized condition, planned comparisons revealed equivalent first block recall by the 6-year-olds in the Forget-Only and Forget-All tasks, $t(7) = .55$ $p >.05$, $\eta^2 = .04$. The 8-year-olds recalled significantly more words in the first block of the categorized Forget-All DF task in comparison to the first block of the categorized Forget-Only DF task, $t(7) = 2.60$, $p <.05$, $\eta^2 = .49$. In the Unrelated condition, planned comparisons revealed equivalent first-block recall across both tasks for both the 6- and 8-year-olds, $ts(7) \leq .74$, $p > .05$, $\eta s^2 \leq .07$. No other main effects or interactions were found (*partial* $\eta s^2 \leq .06$). These results suggest that the 8-year-olds' performance follows patterns of response inhibition in the Categorized condition, but not in the Unrelated condition. Six-year-olds did not produce response inhibition patterns of recall in either condition. This conclusion is supported by the effect size estimations that indicate a much larger effect in the 8-year-olds in the Categorized condition than in the other three Age × Condition groups.

Recognition

Inhibition in recall was confirmed by determining that the TBF words not recalled were as available in memory as the TBR words and were accessible through a recognition test. As discussed earlier, recognition of the TBF and TBR words are tested because lower recall *and* lower recognition of the TBF words in comparison to the TBR words has been interpreted as indicative of selective encoding of the TBR information, and not of retrieval inhibition of the TBF words (Lehman *et al.*, 2001). Mean number of words recognized (and standard deviations) are presented for each Task × Condition × Age × Block cell in Table 2.

A 3 (Task: Remember, Forget-All, and Forget-Only) × 2 (Condition: Categorized, Unrelated) × 2 (Age: 6, 8) × 2 (Block: 1, 2) analysis of variance was conducted on the recognition scores. A main effect of Task was found, $F(2, 56) = 3.44$, $p <.05$, *partial* $\eta^2 = .11$. *Post hoc* comparisons revealed greater recognition in the Remember task ($M = 18.44$) and the Forget-All task ($M = 18.00$) than in the Forget-Only task ($M = 17.28$), $ts(31) \geq 2.46$, $p <.05$, $\eta^2 \leq .16$. The difference in recognition in the Remember task and in the Forget-All task was not significant, $t(31) = 1.5$, $p > .05$, $\eta^2 = .07$. A main effect of Condition was found, with more words being recognized from the Unrelated ($M = 18.33$) than the Categorized condition ($M = 17.42$), $F(1, 28) = 5.56$, $p <.05$, *partial* $\eta^2 = 17$. As expected, a main effect of Age was found with more words being recognized by the 8-year-olds ($M = 18.36$) than by the 6-year-olds ($M = 17.40$), $F(1, 28) = 6.08$, $p <.05$, *partial* $\eta^2 = .18$. A main effect of Block was also

Table 2. Mean recognition as a function of task, condition, age and block

	Task		
	Remember	Forget-All	Forget-Only
Categorized condition			
Six-year-olds			
Block 1	9.00 (1.07)	7.88 (1.55)	8.88 (1.36)
Block 2	8.88 (0.99)	7.87 (1.36)	8.38 (1.92)
Eight-year-olds			
Block 1	9.50 (0.76)	8.75 (1.49)	9.38 (1.06)
Block 2	9.13 (0.64)	8.63 (0.92)	8.25 (1.04)
Unrelated condition			
Six-year-olds			
Block 1	8.88 (1.36)	8.62 (1.77)	9.13 (1.13)
Block 2	8.87 (1.25)	8.63 (0.74)	9.38 (0.92)
Eight-year-olds			
Block 1	9.88 (0.35)	9.63 (0.52)	9.75 (0.46)
Block 2	9.25 (0.89)	9.13 (1.13)	8.88 (1.13)

Note. Standard deviations are shown in parentheses.
Maximum possible recognition in each cell = 10.

found, F (1, 28) = .4.59, p <.05, *partial* η^2 = .14, with higher recognition being found in Block 1 (M = 9.10) than in Block 2 (M = 8.77). No interactions were found (Task × Related and Block × Grade *partial* ηs^2 = .1, all other interactions *partial* $\eta s^2 \leq .06$). Most importantly, recognition scores were above chance (5) for each Task × Condition × Age × Block cell, and estimates of effect size showed very large effects, $ts(7) \geq 5.26$, p <.05, $\eta s^2 \geq .8$. Overall, the pattern of recognition scores, including above chance recognition for each Task × Condition × Age × Block cell, and very large estimations of effect size, are consistent with the interpretation that encoding differences in TBF and TBR recall in both the Forget-All and Forget-Only DF tasks, and in both conditions, did not produce differences in recall.

Discussion

The purpose of the experiment reported here was to determine if task demands in a block-cued DF task play a role in age-related differences in retrieval and response inhibition. Task demands were decreased by presenting a block-cued DF task that consisted of blocks of semantically related words (Categorized condition). The DF task in the Categorized condition should be less resource consuming than a block-cued DF task that consists of blocks of unrelated words (Unrelated condition). The effect of task demands on age-related differences in retrieval inhibition was investigated by comparing first and second block recall in a Forget-All DF task that consisted of semantically related blocks of words with first and second block recall in a Forget-All DF task that consisted of unrelated blocks of words.

The hypothesis that task demands affect retrieval inhibition was confirmed with the 6-year-olds producing reliably lower TBF in comparison to TBR recall in the Forget-All

DF task in the Categorized condition. This pattern of recall was not found until 8 years of age in the Unrelated condition. These results indicate that retrieval inhibition patterns of recall were found by 6 years of age in the categorized DF task, but not until 8 years of age in the unrelated DF task. This interpretation is supported by the effect size estimations which indicated a much larger effect in the both age groups in the Categorized condition and in the 8-year-olds in the Unrelated condition, than in the 6-year-olds in the Unrelated condition. Recognition data suggest that differences in recall were not due to differences in encoding the TBF and TBR words.

The effect of task demands on response inhibition was investigated by comparing first block recall in the Forget-Only and the Forget-All DF tasks in the Categorized and Unrelated conditions. In the Categorized condition, the 8-year-olds rcalled significantly fewer first block words in the Forget-Only than in the Forget-All DF task, whereas there were no differences in the 6-year-olds recall between these cells. There were no differences in first block recall in the Forget-Only and Forget-All DF tasks at either age in the Unrelated condition. These results suggest that response inhibition patterns of recall were found by 8 years of age in the Categorized condition, but not until after 8 years in the Unrelated condition. This result is supported by the effect size estimations that indicate a much larger effect in the 8-year-olds in the Categorized condition than in the other three groups. These results confirm that response inhibition recall patterns are also found at a younger age in the categorized than in the unrelated task.

In summary, the results reported in this study suggest that task requirements affect both retrieval and response inhibitory efficiency. However, before drawing conclusions based on the results presented in this experiment, several issues need to be addressed.

First, an inspection of Table 1 suggests that although retrieval inhibition patterns of recall were found in both ages, first block recall in the categorized Forget-All DF task increases with age. This is likely a result of the more easily recalled categorized items being more available in memory than the less easily recalled unrelated words (Loftus & Loftus, 1974; Neely, 1976; Postman, 1972; Rundus, 1971). Therefore, when the categorized items are explicitly requested at recall in the Forget-All DF task, more are recalled. A similar phenomenon was found to occur with adult participants in the categorized Forget-All DF task (Wilson, Kipp, & Chapman, in press). The important point is that the 6-year-olds produced retrieval inhibition patterns of recall in the categorized task, but not in the unrelated task.

Secondly, the sample sizes utilized in this study were small. Effect size estimations indicated that experimental power was adequate, but larger samples are generally more agreeable. In addition, both retrieval and response inhibition performance is measured as a function of relative recall. Alternative methods that allow one to measure retrieval and response inhibition using an absolute recall measure should be utilized in future research.

Three conclusions can be drawn from this experiment. First, these results suggest that one is likely to find *both* the presence and absence of efficient inhibition within elementary aged children. Recall that cognitive inhibition is an extension of the limited mental resources hypothesis (Case, 1985, 1995; Case *et al.*, 1982). Cognitive inhibition is speculated to facilitate cognitive processing by allowing the individual to process only relevant information and not waste limited mental capacity processing irrelevant information (Harnishfeger, 1995; Harnishfeger & Bjorklund, 1993). The results of this study suggest that cognitive inhibition itself is also capacity consuming. If the task is sufficiently resource consuming, then too few resources are available for efficient cognitive inhibition. However, if the task is minimally resource consuming then cognitive inhibition can facilitate task completion. One must, therefore, take the demands of the task into consideration when interpreting the inhibitory ability of a child, as one is likely to find inhibitory efficiency at younger ages in less resource consuming tasks.

A second conclusion that can be drawn from this study is related to the fact that differences in the age of inhibitory efficiency in tasks that tap different processes are often used to support the notion of domains of inhibitory abilities. As mentioned earlier, Dempster (1993) proposed that there are three domains of inhibitory efficiency: motor, perceptual, and linguistic inhibition. This delineation is based upon evidence that inhibition develops first within motor tasks, then within perceptual tasks, and finally within linguistic tasks. Harnishfeger (1995) suggested that the inhibition of behaviour and the inhibition of cognition are two domains of inhibition. This distinction is based upon the fact that inhibition develops at an earlier age in behavioural tasks than in cognitive tasks. The results of the current study suggest that these results may not have been a product of different domains of inhibitory ability, but instead a product of differences in the difficulty of the tasks used to measure inhibitory efficiency in each domain. The inhibition construct should be re-examined with respect to the different categories of inhibition that have been proposed (e.g. behavioural/cognitive, intentional/unintentional, etc.) to delineate age-related differences in inhibitory performance that are an artifact of task from the age-related differences in inhibition that are a product of developmental differences.

Finally, studies investigating the age-related differences in intentional cognitive inhibition classify children as either mature or immature inhibitors in an all-or-nothing fashion (Harnishfeger & Pope, 1996; Kipp & Pope, 1997; Kipp *et al.*, 1998; Lorsbach & Katz, 1998; Pearson & Lane, 1990, 1991), because it has been difficult to develop a method of determining 'degrees' of inhibitory efficiency. The results of the current study suggest that task differences could be used to measure 'degrees' of inhibitory ability, with efficiency in a less resource-demanding task but not in a more resource-demanding task indicating a certain level of inhibitory ability.

Acknowledgements

The authors would like to thank Nancy Adkinson, Stacy Irby, Samantha Roberts, Brandi Smith and Amy Szarkowski for assistance with data collection. We would also like to thank Cathy Clement and Mark Wilson for comments on earlier versions of this manuscript. Portions of this research were presented at the meeting of the annual meeting of the Southeastern Psychological Association, Savannah, GA, March, 2000, the meeting of the Cognitive Developmental Society, Chapel Hill, NC, October, 1999, and the Conference on Human Development, Mobile, AL, March, 1998.

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Received 24 August 2001; revised version received 11 June 2002