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Developmental Changes in the Inhibition of Previously Relevant Information

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This study examined whether developmental differences exist in the ability to suppress irrelevant information that has entered working memory. Second graders, sixth graders, and young adults (*M* ages = 7.5, 11.7, and 22.4 years, respectively) were asked to provide the ending for a series of sentences that highly constrained a terminal noun (e.g., ''He mailed the letters without any *stamps.*''). Responses to filler sentences were confirmed with the anticipated ending, whereas responses to critical sentences were disconfirmed with an unexpected ending (e.g., *help*). In either case, participants were instructed to remember the terminal noun (target) that was presented to them. Using another sentence-completion task, memory for both disconfirmed and target nouns was measured implicitly in terms of priming effects. Children, particularly second graders, showed priming effects with disconfirmed nouns, whereas young adults exhibited priming effects only with the target nouns. These results are consistent with the view that there are developmental differences in the ability to inhibit irrelevant information (Bjorklund & Harnishfeger, 1990; Hasher & Zacks, 1988).

Theories of selective attention attempt to explain how critical, relevant information is processed when accompanied by distracting or irrelevant information. Contemporary models of selective attention emphasize the joint role

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of both activation and suppression mechanisms in the efficient selection of relevant information (e.g., Neill, 1977; Tipper, 1985). Thus, target information presumably receives continuous activation, while irrelevant information is actively suppressed. For example, in the ''activation-suppression'' model of Tipper and colleagues (e.g., Tipper, 1985; Tipper & Cranston, 1985; Tipper & Driver, 1988; Tipper, MacQueen, & Brehaut, 1988) the cognitive representations of both relevant and irrelevant information are activated automatically when a stimulus array is initially processed. With additional time, however, irrelevant information that should be ignored is actively suppressed or inhibited by the individual.

Hasher and Zacks (1988) have developed a framework in which attentional inhibition plays a critical role in regulating the contents of working memory. According to Hasher and Zacks (1988), inhibitory mechanisms affect the operation of working memory in several ways. First, Hasher and Zacks (1988, p. 12) note that, when operating efficiently, inhibitory mechanisms allow only information to enter working memory that is ''along the goal-path of comprehension'' (i.e., information that is consistent with the goals of a listener or reader). Thus, inhibitory processes suppress the activation of ''off-goal-path'' information and prevent such irrelevant information from entering into working memory. Second, in those instances in which irrelevant information enters working memory, inhibitory mechanisms quickly ''dampen the activation of non-goal-path thoughts'' (Hasher and Zacks, 1988, p. 12). Finally, Zacks and Hasher (1994) have more recently noted that inhibition also may maintain attention to selected information by preventing the return of attention to a previously rejected stimulus or thought (Stoltzfus, Hasher, Zacks, Ulivi, & Goldstein, 1993).

The inhibition of task-irrelevant thoughts becomes particularly important in memory and comprehension tasks where there is a change in goals or a change in the structure of information (Zacks & Hasher, 1994). In many instances, the goals of a particular memory task may need to be altered when prior goals have been reached or when new demands must be addressed. ''When a particular goal is satisfied, the recent past may no longer be relevant and, if that is the case, then abandoning the sustained activation of ideas that were connected with the no longer relevant information becomes appropriate'' (Zacks & Hasher, 1994, p. 244). In other situations, the goals may remain the same, but there may be a sudden change in the structure of information. This often occurs in conversations where there is an abrupt shift in the topic or where some unexpected information is shared. Sudden changes in either goals or informational structure require the individual to inhibit formerly relevant thoughts and associations and shift his or her attention to new goals or new information.

Given the relationship between attentional inhibition and working memory, individuals with inefficient inhibitory mechanisms might be expected to include more irrelevant, off-goal-path information in working memory. Includ-

ing irrelevant information in working memory would consume additional capacity that could otherwise be used to process critical, relevant information. In addition, the irrelevant information that is allowed to enter working memory would receive sustained activation and thus would remain active for longer periods of time. For those tasks that require one to shift attention to new goals or new information, individuals with reduced inhibitory control may tend to maintain irrelevant thoughts in working memory or return their attention to previously rejected thoughts. The entrance of irrelevant information into working memory and the sustained activation of such information could also result in the formation of a greater number of inappropriate associations between relevant and irrelevant information (Gerard, Zacks, Hasher, & Radvansky, 1991).

Included within the framework of Hasher and Zacks (1988) is the observation that there may be adult age differences in the ability to suppress irrelevant information. Support for this hypothesis has been supported by a number of recent studies that suggest cognitive aging is accompanied by a decline in the efficiency of those inhibitory processes that control the contents of working memory (see review by Zacks & Hasher, 1994). For example, older adults experience greater difficulty than younger adults on directed forgetting tasks where they are instructed to forget portions of presented information that are designated as irrelevant (Zacks, Radvansky, & Hasher, 1996). Inefficient inhibition is also revealed in those studies where older adults are found to have greater difficulty abandoning no longer relevant information (Hamm & Hasher, 1992) and display greater memory for irrelevant information (Hartman & Hasher, 1991; Kausler & Kleim, 1978) than younger adults.

Bjorklund and Harnishfeger (1990; Harnishfeger & Bjorklund, 1993) have proposed an extension of the Hasher and Zacks (1988) model to account for developmental differences on a variety of cognitive tasks. Due to improvements in the efficiency of inhibitory processes, it is argued that as children grow older they become more proficient at preventing irrelevant information from entering into working memory. Younger children possess less efficient inhibitory processes and, consequently, allow more irrelevant information to occupy working memory. Because older children possess more efficient inhibitory processes, they are able to suppress irrelevant information and thereby use working memory more efficiently than younger children. The age-related improvements in inhibition are presumed to result from the maturation of the neurological system.

In support of their proposal, Harnishfeger and Bjorklund (1993; cf. Dempster, 1992; 1993) have documented those studies that have found developmental improvements in inhibitory control. Consistent with developmental changes in inhibition are those studies that have found age-related improvements in the ability to ignore external sources of distraction. The ability to ignore environmental distractions is typically assessed on selective attention tasks where developmental improvements have been observed on tasks such

as speeded classification (Strutt, Anderson, & Well, 1975), selective listening (Doyle, 1973), and Stroop tests (Cormalli, Wapner, & Werner, 1962). Additional support for developmental differences in inhibition has been obtained using the negative priming paradigm. Tipper, Bourque, Anderson, and Brehaut (1989, Experiment 3) found that second-grade children, unlike adults, fail to show the negative priming effect. The absence of a negative priming effect suggests that younger children do not inhibit irrelevant information as efficiently as adults. Harnishfeger and Bjorklund (1993) further note that developmental improvements have been found in the ability to inhibit internal sources of distraction. Studies of lexical processing, for example, have found that as children grow older they become more skilled at suppressing word meanings that are inappropriate within a particular context (Simpson & Foster, 1986; Simpson & Lorsbach, 1983).

According to Harnishfeger and Bjorklund (1993), more efficient uses of inhibitory attentional mechanisms may contribute to developmental improvements in memory performance. Because younger children are unable to suppress the activation of irrelevant thoughts, Harnishfeger and Bjorklund (1993) note that younger children have relatively more intrusions of irrelevant information during memory tasks than older children (Brown, Smiley, Day, Townsend, & Lawton, 1977; Shepard, Cohen, Gold, & Orbino, 1976). In a re-examination of data obtained in a previous study of cued-recall performance (Bjorklund & Harnishfeger, 1990), Harnishfeger and Bjorklund (1993) found that younger children make more extra-list intrusions than older children and that such intrusions tend to be more task-inappropriate. More recently, Harnishfeger and Pope (1996) have found evidence of developmental improvement over the elementary school years (grades 1, 3, and 5) in the ability to inhibit the activation and retrieval of task-irrelevant information in a directed forgetting paradigm. These findings suggest that younger children experience difficulty inhibiting irrelevant or competing thoughts on various memory tasks.

The purpose of the present study is to examine whether there are developmental improvements in the ability to inhibit information that is no longer relevant in a memory task. The procedure is patterned after one that was used in recent studies of inhibitory processes in older adults (Hartman, 1990; Hartman & Dusek, 1993; Hartman & Hasher, 1991) and one that has recently been used to compare the efficiency of inhibitory processes in learning disabled and nondisabled children (Lorsbach, Wilson, & Reimer, 1995). During the study phase of the experiment, subjects are asked to generate aloud the terminal nouns for each of a series of high-cloze sentences (e.g., ''We made a sandwich with peanut butter and . . . *jelly.*''; ''He mailed the letters without any . . . *stamps.*''). For half of the sentences (filler sentences), the responses generated by the subject are subsequently confirmed by the presentation of the expected sentence ending (e.g., ''Butterflies fly by flapping their *wings.*''). For the remaining half of the sentences (critical sentences), the subject's response

is disconfirmed with an unexpected ending (e.g., ''He mailed the letters without any *help*''). In either case, subjects are instructed to remember the terminal noun that is presented by the experimenter (target item), rather than the noun that they had previously generated (disconfirmed item). Because subjects must occasionally suppress the activation of words that they have generated, the procedure represents a form of directed ignoring. During the second phase of the experiment, memory for the disconfirmed (e.g., ''*stamps*'') and target (e.g., ''*help*'') nouns for each critical study-sentence are tested implicitly with a new sentence-completion task that does not make any explicit reference to the previous study phase. Here subjects are merely asked to complete new medium-cloze sentences (e.g., ''The package was not sent because it did not have any . . .''; ''My teacher asked me if I needed some . . .'') with the first word that comes to mind. The dependent measure is the amount of priming that is observed with both target and disconfirmed nouns.

The term ''priming'' generally refers to the amount of facilitation that accompanies the processing of old, relative to new, stimulus events. In the case of the current investigation, priming refers to an increase in the frequency above baseline in which subjects complete critical test sentences with previously disconfirmed (e.g., ''stamps'') or target (e.g., ''help'') nouns (Hartman & Hasher, 1991). Those words that have been permitted to receive sustained activation in working memory should display greater amounts of priming. If subjects sustain the activation of target words and efficiently suppress the activation of disconfirmed words that have entered working memory, then priming should be greater for targets than disconfirmed words. On the other hand, if subjects use inhibitory processes inefficiently, disconfirmed items should be permitted to receive sustained activation. Depending upon the amount of activation that disconfirmed items receive, the amount of priming associated with disconfirmed words could be greater than, or equal to, that observed with target words.

Priming is generally regarded as an implicit test of memory (Schacter, 1987). The use of an implicit, as opposed to an explicit, test of memory has a number of advantages in the current procedure (see discussion by Hartman & Hasher, 1991). In contrast to explicit tests of memory, implicit tests of memory do not require the ability to consciously access prior events in memory. If one were to observe age differences with an explicit test of memory (e.g., recognition or recall) in the present experiment, such differences might simply reflect age differences in the use of memory strategies, thus affecting the ability to consciously bring back to mind words that have been recently presented. In addition, age differences on an explicit test could merely reflect differences in the ability to discriminate targets and disconfirmed words, or old and new words at the time of retrieval. Although developmental differences are widespread when memory is tested explicitly, these differences are absent when memory is tested implicitly on tasks that do not require conscious recollection (see reviews by Mitchell, 1993; Naito & Komatsu, 1993; Parkin,

1993). For example, although older children and adults may recognize or recall more information than younger children, these age differences are absent when memory is tested implicitly through the use of repeated picture naming (Carroll, Byrne, & Kirsner, 1985; Lorsbach & Morris, 1991), picture-fragment completion (Lorsbach & Worman, 1989; Parkin & Streete, 1988), word-fragment completion (Naito, 1990), and priming in a word production task (Greenbaum & Graf, 1989). The use of an implicit test in the current experiment allows one to measure possible age differences in the availability of targets and disconfirmed words in the absence of any conscious retrieval processes. Given the absence of any age-related changes with implicit tests of memory, any age differences that are found in the priming of disconfirmed and target nouns must be attributed to mechanisms that control the activation and inhibition of information that enters working memory.

In order to obtain more information about the developmental course of inhibitory processes, the current study tests second graders, sixth graders, and young adults with the Hartman and Hasher (1991) procedure described above. The model of Bjorklund and Harnishfeger (1990; Harnishfeger & Bjorklund, 1993) predicts that there should be developmental improvements in the ability to suppress task-irrelevant information. Assuming the existence of developmental differences in inhibition, second graders should experience relatively greater difficulty than sixth graders and college students in suppressing disconfirmed nouns that have become irrelevant in a memory task. A failure to suppress disconfirmed nouns that have entered working memory would result in irrelevant information consuming capacity that could otherwise be used to process critical target nouns. Thus, as a result of their immature ability to suppress irrelevant information, second graders are expected to exhibit significantly greater priming with disconfirmed nouns than with target nouns. Such differences in priming between disconfirmed and target nouns would be due to the prolonged maintenance of disconfirmed nouns at the cost of failing to maintain the activation of target nouns in working memory. Given the results that have previously been obtained by Hartman and colleagues (Hartman, 1990; Hartman & Dusek, 1993; Hartman & Hasher, 1991), inhibitory processes should be relatively efficient in younger adults. That is to say, younger adults should display relatively greater priming effects with target nouns than with disconfirmed nouns. Predicting effects with the sixth grade children becomes more difficult. It is conceivable that inhibitory processing is fully developed by the time children reach the sixth grade.

METHOD

Subjects

Three age-levels (second grade, sixth grade, and college undergraduates) were represented in the experiment, with each age level consisting of 24 subjects (12 males and 12 females). The mean chronological ages of the three groups were

7.5 (*SD* = .5), 11.7 (*SD* = .48), and 22.4 (*SD* = 4.63). The three age-groups were comparable in terms of their racial and ethnic composition, with 22 Whites and 2 Hispanics in grade two, 22 Whites, 1 Hispanic, and 1 Asian in grade six, and 20 Whites, 3 African-Americans, and 1 Native American in the college group. All subjects had English as their native language.

Materials

The materials and procedures were similar to those used by Hartman and Hasher (1991). Study-list materials were created by generating a pool of 24 sentence frames that highly constrained a terminal noun, yet still allowed for the possibility of an alternate response (e.g., ''We made a sandwich with peanut butter and . . .''). The use of high-cloze sentence frames was designed to elicit specific terminal nouns from subjects during the study phase of the experiment. The majority of these sentence frames were obtained from a previous study by Lorsbach, Melendez, and Carroll-Maher (1991) and from the norms of Bloom and Fischler (1980). The remaining sentence frames were developed specifically for this study. Sentences were selected after three rounds of pilot testing with fourth-grade children.

A high-probability response and an alternate, low-probability response was generated for each of the 24 sentence frames. Each high-probability response represented the expected ending for its corresponding sentence frame (e.g., ''We made a sandwich with peanut butter and *jelly.*''; ''He mailed the letters without any *stamps.*''), whereas the low-probability response provided an unexpected, yet reasonable response to the sentence frame (''We made a sandwich with peanut butter and *bananas.*''; ''He mailed the letters without any *help.*''). The high-probability responses and the low-probability responses are here referred to as ''disconfirmed'' nouns and ''target'' nouns, respectively. For each sentence frame, the unexpected response (target) was presented after the subject had generated the anticipated sentence ending and, thus, disconfirmed the subject's response. These unexpected sentence endings always served as the to-be-remembered nouns (targets). The pool of 24 study sentences was subsequently divided into two subsets of 12 sentences each. Two random versions of each subset were created and used equally often with each of the three age groups.

In addition to the 12 critical sentences, the study list also included 12 filler sentence frames that highly constrained their terminal nouns (e.g., ''Butterflies fly by flapping their *wings.*''; ''I learned how to sing a new *song.*'' Unlike the critical study sentences, however, the terminal nouns of filler sentence frames were never disconfirmed with a low-probability ending. Finally, two practice sentences were used with each subject, with one sentence containing a high-probability ending and the other a low-probability ending.

Each subject was presented with a 24-item study list, consisting of 12 critical sentences from one of the two subsets, along with the 12 filler sentences. Presenting critical sentences in the context of filler sentences was done

in order to increase the likelihood that subjects would anticipate the high-probability terminal noun that was associated with each critical sentence frame. Critical sentences and filler sentences were presented randomly, with the restriction that no more than 3 critical sentences appear in succession. Two filler sentences were placed at the beginning and at the end of the study list in order to minimize the possibility of primacy and recency effects.

The disconfirmed nouns, target nouns, and filler nouns were similar in their mean frequency of occurrence in the language, with the mean frequency count-per-million being 170 (SD = 255), 158 (SD = 239), and 166 (SD = 251), respectively, (Carroll, Davies, & Richman, 1971). In addition, the disconfirmed nouns (M = 5.9, SD = .5), target nouns (M = 5.6, SD = .9), and filler nouns (M = 5.9, SD = .6) were similar in their rated concreteness (Toglia & Battig, 1978; Paivio, Yuille, & Madigan, 1968; Gilhooly & Logie, 1980).

Test-list materials consisted of 48 sentence frames that moderately constrained their respective terminal nouns. Twenty-four of the 48 sentence frames were designed to indirectly test memory for the disconfirmed nouns and the target nouns from the preceding study list. Of these 24 sentence-frames, 12 tested the disconfirmed nouns, and 12 tested the target nouns. To illustrate, the study sentence frame, ''We made a sandwich with peanut butter and _.'', had a high-probability response (''jelly''), as well as a low-probability ending (''bananas''). In this case, ''jelly'' provided the anticipated, but disconfirmed ending, whereas ''bananas'' provided the low-probability ending and served as the to-be-remembered target noun. Memory for the 12 disconfirmed endings (e.g., ''jelly'') was tested indirectly by presenting moderately constrained sentence frames (e.g., ''The fly landed on the jar of _.''). Memory for the 12 target items (e.g., ''bananas'') was tested similarly with other moderately constrained sentence frames (e.g., ''The man peeled and ate two _.''). The Appendix provides a complete listing of test sentences and their corresponding cloze values according to age and condition. The remaining 24 sentence frames were the test items for the alternate subset of study sentences that were not presented to the subject. These latter sentences provided the baseline (control) condition for each subject.

Two different random orders of presentation were generated and were used about equally often with each age group. Each of the two random orders of presentation included the additional constraint that no more than 3 items from each subset be presented in succession.

Procedure

Each subject was tested individually in a quiet room. The study sentences were tape-recorded for presentation by an adult male at 13 s intervals. Each stimulus interval began with the presentation of a given sentence frame. The duration of each sentence frame varied somewhat, depending upon the length of the frame itself. In most instances, however, the presentation of the sentence

frame required about 2 s. Six seconds later the terminal noun was presented. Following a 5 s interstimulus interval, the next sentence frame was presented.

Each subject was told that he or she would be listening to a list of sentences. Subjects were asked to listen to each sentence as it was presented and to try to remember the last word for a subsequent memory test. Each subject was also told that there would be a pause before the presentation of the final word within each sentence. During this pause the subjects were requested to predict the final word aloud. The experimenter recorded the nouns that were produced by each subject. In addition, each subject was cautioned that some of the sentences contained unexpected endings. Regardless of whether the word was anticipated or unanticipated, children and adults were asked to try to remember only the word that was actually presented on the audio-tape. Following these instructions, each subject was given two practice sentences. One practice sentence presented an expected sentence ending, and the other sentence an unexpected ending.

Immediately following the presentation of the 24 study sentences, each subject was given a digit-symbol substitution task from the *Wechsler Adult Intelligence Scale* (Wechsler, 1955). This activity merely served as a nonverbal filler activity and was terminated when 5 min had expired.

After the filled-retention interval, the sentence completion test was administered. This task was not presented as a memory test of the previous study sentences. Rather, subjects were informed that they would be hearing a new set of sentences. They were asked to listen to and promptly complete the new sentences with the first word that comes to mind. The experimenter read the incomplete sentences aloud and recorded the subject's response to each sentence.

Following the procedures set forth in previous research (Hartman & Hasher, 1991), an attempt was made to determine whether each subject was aware of the relationship between study and test materials. Upon completion of the testing session, each subject was asked about his or her awareness of the relationship between study and test sentences. Subjects were asked initially two general, non-leading questions: ''What did you think of the research activity?'' and ''Did you think there was anything unusual about the study sentences?'' If subjects indicated that they had noticed anything unusual about the sentences, then they were questioned more explicitly about the relationship between the study and test lists (i.e., whether they had noticed any connection between the two lists, and if so, what they noticed and when). If a subject expressed an awareness of the relationship between the two sentence lists, he or she was then asked whether a conscious attempt had been made to use (or avoid using) the terminal nouns of study sentences as endings for the second sentence-completion task.

RESULTS

An alpha level of .05 was used for all statistical tests. For each subject, the proportion of ''correct'' sentence completions on the test list was calcu-

TABLE 1
Mean Proportion of Test Sentences in which Subjects at Each Age Level Generated Terminal Nouns in the Disconfirmed, Target, and Control Condition

	Condition		
Age level	Disconfirmed	Target	Control
Grade Two	.49 (.18)	.36 (.13)	.36 (.11)
Grade Six	.53 (.14)	.52 (.26)	.43 (.12)
College	.51 (.18)	.66 (.15)	.47 (.11)

Note. Proportions for each subject in the disconfirmed condition were based upon the number of sentences (maximum = 12) in which the disconfirmed noun was generated during the study phase. Proportions in the target condition were based on the number of sentences (maximum = 12) in which the target noun was *not* produced during the study phase. Proportions were based 24 sentences in the control condition. Standard deviations are in parentheses.

lated for each of three conditions: (a) disconfirmed condition: the proportion of those test sentences that were completed with the disconfirmed nouns from the preceding study list; (b) target condition: the proportion of those test sentences that were completed with the target nouns from the preceding study list; and (c) control condition: the proportion of test sentences that were completed with the disconfirmed and target nouns from the alternate set not presented to a given subject. Table 1 presents the mean proportions of these ''correct'' sentence completion rates for each age group in the disconfirmed, target, and control condition. The three proportions were used to calculate priming scores in both the disconfirmed and target condition. Priming effects associated with the disconfirmed and target conditions were calculated separately by subtracting the control score from each of the respective conditions. These difference scores, therefore, reflect priming effects in the disconfirmed and target conditions over and above any age differences that might exist in a baseline sentence-completion task.

Three constraints were imposed on the computation and use of priming scores. First, the calculation of individual priming scores in the disconfirmed condition was contingent upon whether subjects generated the high-cloze ending for a given sentence in the study list (e.g., ''We made a sandwich with peanut butter and *jelly.*''). If, instead of providing the high-probability response, a subject provided another response (e.g., ''bread'' in the above example), the test sentences for both the disconfirmed noun (''jelly'') and the target noun (''bananas'') were not included in the calculation of the subject's priming score. Of the 12 critical sentences, second grade, sixth grade, and college students failed to provide high-probability responses an average of 2.4 (SD = 1.21), 1.8 (SD = .94), and 1.8 (SD = 1.27) times, respectively. These ''error rates'' in generating disconfirmed nouns did not vary significantly with age, $F(2,69) = 2.384$, $MSE = 3.167$, and $p > .05$.

The comparability of group means indicates that the number of test sentences used in the computation of priming scores in the disconfirmed condition did not vary significantly across the three age groups.

The second constraint involved the calculation of priming scores in the target condition. Although target nouns provided low cloze and, therefore, unlikely endings for the study sentences, there were a few times in which subjects generated target nouns in response to the sentence frame. In those instances, the test sentence for that target noun, as well as the test sentence for the corresponding disconfirmed noun, were excluded from the calculation of that subject's priming scores. Of the 12 critical sentences, second grade, sixth grade, and college students provided low-probability responses (targets) an average of .25 (SD = .53), 0, and .29 (SD = .55) times, respectively. As with the disconfirmed condition, the number of sentences in which subjects generated the target word did not vary significantly among the three age groups, $F(2,69) = 3.062$, $MSE = .597$, and $p > .05$.

The third constraint involved determining whether the subject expressed any awareness of the relationship between the nouns used in the completion of study and test sentences. If a subject expressed an awareness of the relationship between the study and test sentences and attempted to use their awareness of that relationship to complete various test sentences, that subject's data was not included in the analysis. In reflecting upon the task, a few of the younger adults indicated that there may have been some relationship between study and test items, but they were unable to specify the nature of that relationship. Beyond having some vague sense of a possible relationship between study and test sentences, however, these subjects indicated that they did not attempt to use or avoid using the terminal nouns of the study sentences as endings for the test sentences.

Before priming effects were examined, a preliminary analysis of sentence completion rates was performed in order to determine whether the three age groups responded differently as a function of sentence type (target or disconfirmed) in the control condition. Including sentence type in the analysis not only yields more detailed information about the control items, but also provides important information about the cloze probabilities of those same sentences when they are used in the test condition. This is possible because in the design of this experiment those sentences that served as controls for half of the subjects were the same sentences that served as test sentences for the remaining half of the subjects.

Completion rates of control sentences were submitted to a 3×2 mixed design Analysis of Variance (ANOVA), with age (grade two, grade six, and college) as the between subjects factor and sentence type (disconfirmed or target) as the within subjects factor. This analysis revealed that the three age groups differed in their overall sentence completion rates in the control condition, $F(2,69) = 6.083$, $MSE = .025$, and $p = .0037$. The means for grade 2, grade 6, and college were .36, .43, and .47, respectively. Post hoc

comparisons using the Newman Keuls test indicated that college students produced higher cloze values for control sentences than second graders and sixth graders, but that the latter two age groups did not differ significantly from each other. As described previously, the computation of priming scores in both the target and disconfirmed conditions take into consideration these group differences in the control condition. Thus, any age differences found in disconfirmed or target priming scores reflect group differences beyond those found to exist in the control condition. There was no effect of sentence type ($F < 1$), nor did it interact with age, $F(2,69) = 1.012$, $MSE = .021$, and $p > .10$. The fact that sentence type was not significant and did not interact with age indicates that disconfirmed and target test items yielded equal sentence completion rates across the three age groups. Therefore, this rules out the possibility that any age differences in priming that are observed reflect differences in the probability of producing terminal nouns on disconfirmed or target sentences on the test list.

Priming scores were submitted to a 3×2 mixed design ANOVA, with age (grade 2, grade 6, or college) as the between-subjects variable, and priming condition (disconfirmed or target) as the within-subjects variable. Although the main effects of age and priming condition were not significant (both Fs < 1), the age *x* priming condition interaction was significant[1], $F(2,69) = 9.921$, $MSE = .023$, and $p = .0002$. Figure 1 shows the mean proportion of priming scores in the disconfirmed and target condition for each age group.

The age *x* priming condition interaction was examined further by separately testing the effects of priming condition at each age. Simple effects tests revealed that second-grade children experienced significantly greater priming with disconfirmed words than with target words, $F(1,69) = 7.844$, $MSE = .023$, and $p = .004$. *T* tests were performed to examine whether these priming effects were significantly greater than zero. The results of these *t*-tests indicated that priming was significantly greater than zero for the disconfirmed words, $t(23) = 3.6$, $p < .01$, but not for the target words, $t < 1$. Thus, second-grade children implicitly remembered only the previously disconfirmed words, but not the target words.

Simple effects tests indicated that sixth-grade children experienced equiva-

[1] The scores used in the current analysis reflect absolute differences in priming effects. Because of age differences in the control condition, there is the possibility that age differences in priming may disappear when alternate forms of analysis are used that consider group differences in baseline performance. Therefore, an additional analysis was performed by comparing proportional gain scores. The analysis of these gain scores yielded results that were essentially identical to the analysis of absolute differences. Most importantly, the age $\times$ priming condition interaction remained significant, $F(2,69) = 5.423$, $MSE = .194$, and $p = .0065$. The only difference was in the subsequent simple effects analysis of priming condition with second-grade children. Although the trend was similar, the effect of priming condition that had been significant at grade two in the analysis of absolute differences, becomes marginally significant in the analysis of these transformed scores, $p = .067$.

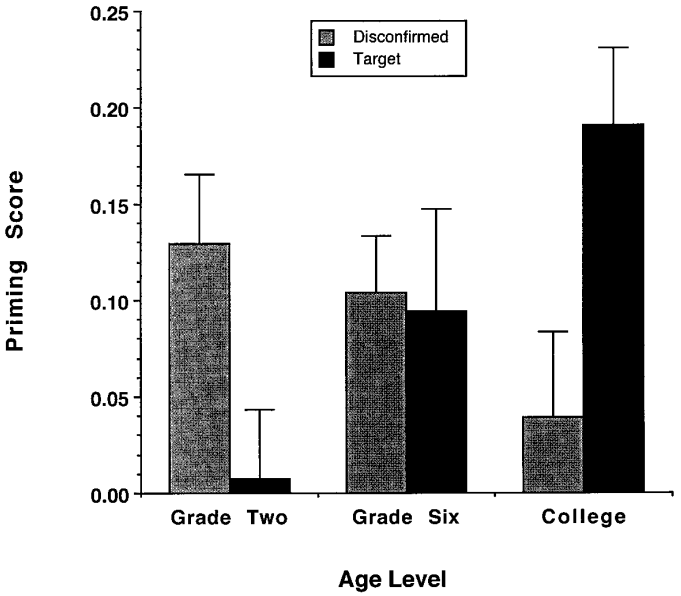

FIG. 1. Mean proportion of priming scores for disconfirmed and target nouns as a function of age. Error bars represent standard error.

lent amounts of priming for disconfirmed and target words ($F < 1$). Priming effects were significantly greater than zero for the disconfirmed nouns, $t(23) = 3.456$, $p < .01$, and approached significance with the target nouns $t(23) = 1.768$, $p < .10$. The marginal effect of target priming, in this case, may be attributed to the fact that the priming of target nouns produced larger variance ($SD = .26$) than did the priming of disconfirmed nouns ($SD = .149$). These results suggest that sixth-grade students remembered both disconfirmed and target nouns.

Finally, simple effects tests indicated that the college undergraduates exhibited significantly greater priming with target words than with disconfirmed words, $F(1,69) = 12.024$, $MSE = .023$, and $p = .001$. For the college students, priming effects were significantly greater than zero with only the target items $t(23) = 4.77$, $p < .001$, but not with the disconfirmed items, $t < 1$. Thus, young adults demonstrated implicit memory for target items, but not for the disconfirmed words.

The individual patterns of responding across the three age levels were consistent with the findings that emerged from the analysis of the group data. The number of subjects at each age level was computed for each of three response-patterns: (a) greater priming for targets than disconfirmed nouns, (b) greater priming for disconfirmed than target nouns, and (c) equivalent priming for target and disconfirmed nouns. At grade two, 4 of the 24 subjects

exhibited relatively greater amounts of priming for targets than disconfirmed nouns, whereas 16 of the 24 subjects experienced greater priming for the disconfirmed nouns. Four remaining second-graders displayed equal amounts of priming with the disconfirmed and target nouns. At grade six, 10 of the 24 subjects exhibited greater priming for targets, and 11 of the 24 sixth-graders showed greater priming for the disconfirmed than target nouns. Three remaining sixth-graders displayed equal amounts of priming with disconfirmed and target nouns. For the college students, 16 of 24 subjects displayed greater priming for targets, whereas 4 of 24 exhibited greater priming with disconfirmed nouns. Four remaining young adults showed equal amounts of priming for targets and disconfirmed nouns. Using a Chi-square test, the differences between the observed and expected frequencies for the three response patterns in the three age groups were found to be significant, $\chi^2(4) = 12.046$, $p < .02$.

When considered collectively, the above analyses are consistent with age-related improvements in the efficiency of inhibition. The development of attentional inhibition may be observed in the relative amounts of priming that were associated with disconfirmed and target nouns at each age level. Because of their immature ability to suppress task-irrelevant information, second graders failed to inhibit disconfirmed nouns and reallocate their attention to target nouns. Sixth-graders also experienced difficulty with suppression in that they maintained the activation of both disconfirmed and target nouns. College students, on the other hand, suppressed the disconfirmed nouns and reallocated their attention to the target nouns. Of particular importance were those analyses that examined the statistical reliability of the priming effects of target and disconfirmed nouns at each age level. T-tests revealed that although both groups of children revealed reliable priming effects in the disconfirmed condition, priming in the disconfirmed condition was not reliably greater than zero with the college students. Thus, only college students effectively suppressed the words that had been previously disconfirmed.

The scoring method used in the preceding analyses involved calculating the proportion of words generated by the subject that matched the sentence completions on the test list in each of three conditions: disconfirmed, target, and control. Differences in the proportions between the critical (disconfirmed and target) and control condition were then used to independently assess priming in each of the critical conditions. This scoring method reflects the priming of all those disconfirmed nouns that had been produced by the subject, separately, from all those target nouns that had been provided by the experimenter during the preceding study trials. Although this scoring method yields important information about the relative amounts of priming that occurred with disconfirmed and target nouns, it does not indicate whether subjects had indeed replaced the disconfirmed noun with its corresponding target noun in a given study sentence. Therefore, a second scoring method was devised that captures both the suppression of disconfirmed nouns *and* the activation of

target nouns in a single composite score. This composite score, in a sense, reflects the reciprocal nature of both activation and suppression processes that exist within the Hartman and Hasher (1991) task. This scoring method examined directly whether or not the suppression and replacement that had occurred during a specific study-trial resulted, later, in a subject being more likely to generate the target word than its corresponding disconfirmed word in a new sentence-completion task. This scoring method takes advantage of the systematic relationship that exists between study and test lists. That is to say, the disconfirmed and target words that were used in a given study sentence each were later tested with new incomplete sentences on the test list. A measure of suppression was obtained by directly comparing the completions of those disconfirmed and target test-sentences that were paired with a specific study sentence. Evidence of suppression was obtained whenever a subject generated the target, but not the disconfirmed word in these two test-sentences. The raw score for a subject, therefore, was the number of paired sentences for which the target but not the disconfirmed word was generated, minus the number of pairs in which the reverse occurred (i.e., generation of the disconfirmed, but not the corresponding target word). Pairs for which both or neither of the words were generated did not contribute to the scores. To take into account the fact that the number of test-sentence pairs varied across subjects, the raw scores were converted to proportions. Because of the manner in which these suppression scores were derived, positive scores are indicative of suppression, whereas negative scores reflect a failure to suppress.

This same scoring method was similarly applied to the control sentences. This was possible because the design of this study involved the use of two subsets, with the unused subset serving as the controls for a given subject. The 24 control sentences were scored in the same pairwise manner that was used in calculating the suppression scores of the critical test sentences. Using this scoring method, evidence of a developmental improvement in suppression would be found if suppression scores for the test items showed an increase across age, while scores for the control sentences were similar for the three age groups.

Sentence pairs that met the above scoring criteria (as well as the 3 constraints that were imposed upon the calculation of priming scores) were submitted to a 3×2 mixed design ANOVA, with age (second grade, sixth grade, and college) as the between subjects factor, and sentence type (test or control) as the within subjects factor. The mean number of test sentence-pairs included in this analysis was 4.8 for the second-graders, 4.9 for the sixth-graders, and 4.8 for the college students. The mean number of control sentence-pairs included in this analysis was 4.5 for the second-graders, 5.4 for the sixth-graders, and 5.6 for the college students. The effect of age, $F(2,69) = 8.398$, $MSE = .044$, and $p = .0005$, was significant. In addition, the age $\times$ sentence type interaction was significant, $F(2,69) = 4.194$, $MSE = .041$, and $p = .0191$.

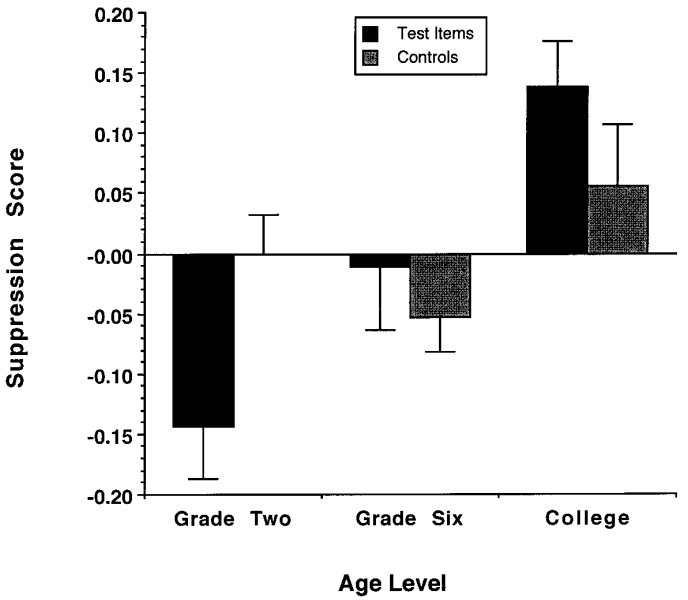

FIG. 2. Mean suppression scores for test and control items as a function of age. Positive scores reflect successful suppression, whereas negative scores indicate a failure to suppress previously disconfirmed nouns. Error bars represent standard error.

The age *x* sentence type interaction is displayed in Fig. 2. This 2-way interaction was examined further by separately testing the simple effects of age with each sentence type. Tests of the simple effects of age with each sentence type revealed that although there were no age differences with the control sentences, $F(2,69) = 1.922$, $MSE = .037$, and $p > .10$, there were significant age differences with test sentences, $F(2,69) = 9.745$, $MSE = .049$, and $p = .000$. Post hoc comparisons indicated that the mean suppression scores of second-graders on the test sentences were significantly lower than those of sixth-graders, and that the suppression scores of sixth-graders were, in turn, significantly smaller than those of college students. Thus, a significant age-related increase was found in the ability to suppress disconfirmed nouns in the absence of any age differences in the control condition.

The individual patterns of response for each of the three age levels paralleled the analysis of the group data. At grade two, 15 of the 24 subjects obtained negative suppression scores by showing a greater tendency to generate disconfirmed words than their corresponding targets on the sentence completion task. Only 4 of the 24 second-grade subjects obtained positive suppression scores by generating targets and not their corresponding disconfirmed words from the preceding study sentences. The remaining 5 second-grade children obtained a zero suppression score (i.e., the number of paired senten-

ces in which the target but not the disconfirmed word was generated, equaled the number of paired sentences in which the disconfirmed but not the target word was generated). For the sixth-graders, 11 of the 24 subjects produced more disconfirmed words than their corresponding targets, and 10 of the 24 subjects produced a greater number of target nouns than their corresponding disconfirmed nouns. Three remaining sixth-grade subjects obtained a zero suppression score. Finally, for the college students, only 3 of the 24 subjects obtained negative suppression scores by generating more of the disconfirmed nouns than the target nouns with which they had been paired in the preceding study sentences. In contrast, 15 of the 24 subjects provided more of the targets than their paired disconfirmed nouns. The remaining 6 subjects in this age group obtained a suppression score of zero. As with the earlier analysis of priming score response patterns, the differences between the observed and expected frequencies in the three age groups were found to be significant, $\chi^2(4) = 14.989$, $p < .01$.

DISCUSSION

The analysis of attentional inhibition was based upon two different scoring methods. In each case, the results were consistent with the predictions of the Bjorklund and Harnishfeger framework (1990; Harnishfeger & Bjorklund, 1993), indicating that there are developmental changes in the ability to inhibit verbal information that is no longer relevant in a memory task. The first set of analyses followed the scoring method used in previous research (e.g., Hartman & Hasher, 1991). Although there were no age differences in the overall amount of priming, there were age differences in the relative amounts of priming that were associated with disconfirmed and target nouns. Second-grade children exhibited significantly greater amounts of priming with disconfirmed nouns than with target nouns, with only the disconfirmed nouns being significantly greater than zero. The fact that second-grade children exhibited priming effects with the disconfirmed, but not with the target items, suggests that children at this age experience particular difficulty in their attempts to abandon recently generated information that has become irrelevant. Sixth-grade children, on the other hand, displayed equal amounts of priming with disconfirmed and target nouns. As with the second grade children, the amount of priming associated with disconfirmed nouns was significantly greater than zero. Unlike the second graders, however, the amount of target priming that was above zero approached significance for the sixth graders. Together, these results suggest that the representations of both irrelevant and relevant information may remain active in memory with older children. Unfortunately, this continued maintenance of irrelevant information may ultimately have a rather negative impact upon memory processing in at least two ways. First, the presence of irrelevant information in working memory occupies space that could otherwise be used for processing target information. As a result, the quality of target encodings may be degraded. Second, the sustained activation

of irrelevant information may later compete with relevant information at the time of retrieval and thus lead to output interference.

In contrast to the performance of the two groups of children, the young adults were quite efficient in suppressing disconfirmed information. The efficiency of these inhibitory processes was evidenced by the fact that young adults displayed significant priming effects with only those words that they were instructed to remember, and not with words that they were asked to ignore. Finding that young adults exhibit priming with targets, but not with disconfirmed nouns is consistent with the earlier research of Hartman and colleagues (Hartman, 1990; Hartman & Hasher, 1991; Hartman & Dusek, 1993). Other comparisons between the performance of our young adults and their young adult subjects are not possible because of differences between the two studies. For example, unlike the present study, Hartman and Hasher (1991) required their subjects to silently generate sentence endings and, therefore, were unable to conditionalize scoring on whether subjects generated the correct disconfirmed noun or inadvertently generated the target noun. In an earlier study, however, Hartman (1990, Experiment 2) did report priming effects with younger adults in the disconfirmed condition that were conditionalized upon the correct generation of the disconfirmed word during the study phase. In this case, the priming effect (.033) obtained with young adults in the disconfirmed condition was very similar to the amount of priming that was found with young adults in the current study (.039).

The second set of analyses in the present study were based upon an alternate scoring method that directly compared the completions of disconfirmed and target test-sentences that were paired with a specific study sentence. Again, the results supported the observation that there is developmental improvement in the ability to inhibit information that has become irrelevant in a memory task. Most importantly, when there were no age differences in the control condition, a significant age-related improvement was found in the ability to suppress the disconfirmed nouns.

When considered collectively, the above results may be interpreted within the framework of Hasher and Zacks (1988). According to the Hasher and Zacks (1988) framework, inhibitory mechanisms prevent irrelevant (''off-goal-path'') information from entering into working memory. In those instances when irrelevant information enters working memory, inhibitory mechanisms quickly dampen the activation of irrelevant information. Because of the nature of the procedure used in the current experiment, irrelevant information (disconfirmed noun) is activated and allowed to enter working memory prior to the presentation of relevant information (target noun). The presentation of new, unexpected information requires subjects to inhibit the activation of formerly relevant information and to shift their attention to new information. The results of the present study indicate that there are age-related improvements in the ability to quickly inhibit irrelevant thoughts and associations that have been activated in working memory and to redirect attention

to new information that is appropriate to the goals of both comprehension and remembering.

These developmental changes in inhibition may be described in terms of the growth of what Stoltzfus et al. (1993) have referred to as ''conceptual inhibition of return.'' This term was used by Stoltzfus et al. (1993) to describe how inhibitory processes function when irrelevant information has entered into working memory. Inhibition of return is a perceptual event that is observed during visual search tasks where attention is directed more easily at new locations, than previously attended locations (Posner & Cohen, 1984). Stoltzfus et al. (1993) suggest that inhibition may represent a conceptual analogue of this perceptual phenomenon in that inhibitory processes maintain attention on the target information, and prevent the return of attention to recently rejected distractors. Such a mechanism enables the individual to focus attention on selected ideas without returning to previously rejected thoughts. When this construct is applied to the results of the present study, it suggests that children (particularly younger ones) have greater difficulty than young adults in inhibiting the return of attention to previously rejected ideas.

It is conceivable that the performance of younger children may not reflect a failure to inhibit disconfirmed information, but rather may suggest that they had difficulty encoding the target nouns within the context of their sentence frames. This alternative explanation seems unlikely for several reasons. First, there is nothing about the characteristics of the target nouns that would make processing them more difficult for younger children. Disconfirmed and target nouns were comparable, both in terms of their frequency of occurrence and concreteness ratings. In addition, the preliminary analysis of sentence completion rates of control items on the test list indicated that there were no age differences in the probability of producing disconfirmed and target nouns. Finally, anecdotal evidence in the form of occasional smiles suggested that younger children not only integrated the unexpected target nouns with their respective sentence frames, but also sometimes found humor in them. If younger children experienced difficulty in processing target nouns, it was the direct result of their failure to inhibit the noun that had just been disconfirmed. The failure of younger children to inhibit disconfirmed nouns would have resulted in the maintenance of irrelevant information in working memory for longer periods of time. The sustained activation of the disconfirmed noun in working memory would interfere with the ability to shift attention to the processing of the target noun. Thus, any difficulty with the conceptual integration of target nouns within sentence frames would have been the direct result of younger children failing to effectively inhibit recently disconfirmed nouns. Because of more efficient inhibitory processes, young adults were able to quickly suppress disconfirmed nouns and redirect their attention to the processing of target nouns.

Although the inhibitory processes of young adults appear to be quite efficient, under certain circumstances they may perform like children in that they may

have difficulty suppressing disconfirmed, nontarget information. For example, in her comparison of younger and older adults, Hartman (1990, Experiment 3) used a procedure that was designed to make disconfirmed words salient. Both the disconfirmed and target words were presented simultaneously to subjects, with instructions to select the most unlikely ending to learn for a later memory task. According to Hartman (1990), this procedure requires more ''obligatory processing'' of disconfirmed words than procedures that present disconfirmed and target items successively. Younger adults performed like the sixth-grade children in the present study, in that they exhibited equal amounts of priming for the disconfirmed and target words. The performance of older adults was also negatively affected. In this case, older adults showed greater priming with the disconfirmed than the target items, performance that was similar to that of younger children in the present study.

Finding that there are developmental improvements in the ability to inhibit previously relevant information has significant implications for the growth of memory and language processing abilities in children (see discussions by Bjorklund & Harnishfeger, 1990; Harnishfeger & Bjorklund, 1993; Dempster, 1992, 1993). Earlier in this paper it was noted that more efficient inhibition may be at least partly responsible for the fewer number of intrusions and false recognitions that older children exhibit in memory tasks when compared to younger children (e.g., Bjorklund & Harnishfeger, 1990; Brown et al., 1977; Shepard *et al.,* 1976). Similarly, the maturation of inhibitory processes may contribute to the increased resistance to proactive inhibition that children exhibit as they grow older (Dempster, 1992, 1993). Developmental improvements in inhibition could also be responsible for age differences on tasks measuring selective remembering and intentional forgetting (Harnishfeger & Pope, 1996; Lehman & Bovasso, 1993).

Finally, it is important to note that attentional inhibition is not a single process that manifests itself consistently across various tasks. For example, although young children and older adults fail to reliably show negative priming when the identity of targets has to be reported, they do show negative priming when the location of the targets has to be reported (Connelly & Hasher, 1993; Tipper & McLaren, 1990). Dempster (1993, pp. 18–19) has recently noted that resistance to interference (i.e., the capacity for inhibition) may not be a unitary phenomenon, but rather be a multifaceted process containing a number of operating characteristics. These operating characteristics may vary along three dimensions: temporal (proactive, retroactive, coactive or concurrent), formal (motoric, perceptual, and linguistic), and external vs internal events. Dempster (1993) further speculates that age-related changes in resistance to interference do not occur in a uniform manner with each of the three formal categories (motoric, perceptual, and linguistic). The present study has examined the developmental changes that occur in the inhibition of linguistic information. Further research is needed in each of the formal areas so that a more complete picture is obtained about the development of inhibition in various domains.

APPENDIX
Mean Cloze Values of Study and Test Sentences According to Age

Study and corresponding test sentences[a]	Terminal nouns		Age		
	Disconfirmed	Target	Grade 2	Grade 6	College
1. He filled the bathtub with	water.		.92	.92	1.0
		toys.	.00	.00	.00
For garden plants to grow, they need lots of	water.		.33	.58	.50
Mother said, ‘‘When you finish playing, please put away your		toys.’’	.42	.58	.58
2. He mailed the letters without any	stamps.		.25	.67	.67
		help.	.25	.00	.08
The package was not sent because it did not have any	stamps.		.25	.33	.17
My teacher asked me if I needed some		help.	.25	.50	.25
3. The bright sun was hidden behind a large	cloud.		.42	.67	.58
		mountain.	.08	.00	.00
Look in the sky and see that	cloud.		.08	.58	.67
The men will attempt to climb that steep		mountain.	.33	.17	.42
4. The fireman is fighting a	fire.		.92	1.0	1.0
		cold.	.00	.00	.00
I wanted to warm up, so I stood beside the	fire.		.17	.50	.58
He stayed home from school and took some medicine for his		cold.	.25	.08	.58
5. After seeing the tangles, the girl said, ‘‘I need to brush my	hair.’’		.83	1.0	.83
		dog.	.00	.00	.00
She has very pretty	hair.		.50	.67	.58
The little boy was frightened by the big		dog.	.67	.58	.92
6. The theater was so crowded he could not find his	seat.		.75	.75	.67
		friends.	.00	.00	.17
The student moved because she was in the wrong	seat.		.67	.50	.83
When he left home he amazed his		friends.	.08	.33	.33
7. When it started to rain, they stopped the baseball	game.		.83	1.0	1.0
		party.	.00	.00	.00
My father bought tickets to the	game.		.75	.58	.67
We were having fun until we ran out of food at the		party.	.50	.42	.67
8. The picture is hanging on the	wall.		.58	.83	.83
		hook.	.00	.00	.00
The spider is crawling on the	wall.		.17	.33	.42
The student opened the locker and put his hat on the		hook.	.67	.92	.42
9. The student drew the picture using paper and	pencil.		.50	.58	.58
		chalk.	.00	.00	.00
I wrote the note with a	pencil.		.25	.17	.42
While teaching, Mrs. Jones dropped a piece of		chalk.	.50	.50	.42

APPENDIX–*Continued*
Mean Cloze Values of Study and Test Sentences According to Age

Study and corresponding test sentences[a]	Terminal nouns		Age		
	Disconfirmed	Target	Grade 2	Grade 6	College
10. The carpenter hit the nail with his	hammer.		1.0	1.0	1.0
		truck.	.00	.00	.00
My father went to the hardware store to buy a new	hammer.		.33	.25	.58
That man is driving a big, old rusty		truck.	.00	.00	.00
11. The Indian has a bow and some	arrows.		.92	1.0	1.0
		knives.	.00	.00	.00
He hit the bullseye with two	arrows.		.42	.58	.67
Although dangerous, the circus performer threw several		knives	.50	.58	.67
12. We made a sandwich with peanut butter and	jelly.		.92	1.0	.83
		bananas.	.08	.00	.00
The fly landed on the jar of	jelly.		.33	.17	.67
The man peeled and ate two		bananas.	.17	.17	.00
13. The exit was marked by a large	sign.		.50	.92	.92
		man.	.00	.00	.00
Because it was so dark outside, I could hardly read the	sign.		.75	.58	.33
The woman was introduced to the		man.	1.0	.67	.83
14. The girl had chicken pox and could not go to	school.		1.0	.75	.83
		sleep.	.00	.00	.17
Mary got dressed to go to	school.		.58	.58	.67
Billy was very tired and wanted to go to		sleep.	.50	.50	.67
15. I cannot lock the door without using my	key.		.92	.75	.83
		hand.	.00	.00	.17
Father said, ''We cannot leave unless I find my	key.''		.17	.42	.42
Danny caught the ball with his		hand.	.08	.50	.58
16. Go to the library and check out a good	book.		1.0	1.0	1.0
		magazine.	.00	.00	.00
I cannot do my homework because I forgot my	book.		.25	.42	.17
While reading, I saw a picture of the movie star in the		magazine	.42	.58	.50
17. The cowboy rode on a	horse.		1.0	1.0	1.0
		bicycle.	.00	.00	.00
When we visited the ranch we were able to pet the	horse.		.25	.58	.33
The boy went to play on his new		bicycle.	.33	.17	.33
18. The batter swung and hit the	ball.		.83	1.0	.92
		coach.	.00	.00	.00
As it rolled down the street, the dog chased the	ball.		.00	.25	.17
This year our soccer team will have a different		coach.	.00	.08	.25
19. As he entered the building, the boy took the cap off his	head.		1.0	.83	.75
		bottle.	.00	.00	.00
When he was playing, he bumped his	head.		.58	.92	.42
The catsup dripped from the		bottle.	.33	.33	.17

APPENDIX–*Continued*
Mean Cloze Values of Study and Test Sentences According to Age

Study and corresponding test sentences[a]	Terminal nouns: Disconfirmed	Terminal nouns: Target	Age: Grade 2	Age: Grade 6	Age: College
20. The lawn mower ran out of	gas.		.83	.83	1.0
		oil.	.08	.00	.00
My Mom said, ''We can stop at that filling station and buy some	gas.		.17	.25	.25
The mechanic spilled some		oil.	.25	.33	.67
21. Mice like to eat	cheese.		1.0	.83	.83
		corn.	.00	.00	.00
The sandwich would taste better with a slice of	cheese.		.58	.42	.17
The farmer is harvesting the		corn.	.50	.50	.67
22. Don't touch the wet	paint.		.25	.17	.25
		puppy.	.00	.00	.00
The old house needs some	paint.		.33	.75	.67
The boy could not think of a name for the furry little		puppy.	.42	.67	.50
23. For breakfast, I ate a bowl of	cereal.		1.0	1.0	.92
		fruit.	.00	.00	.00
My father put some fresh strawberries on his bowl of	cereal.		.08	.25	.33
You should eat plenty of fresh		fruit.	.00	.17	.50
24. They used an ambulance to rush the man to the	hospital		.92	1.0	1.0
		airport.	.00	.00	.00
When I injured my hand, I went to the	hospital.		.33	.08	.08
They took a cab to the		airport.	.42	.33	.52

[a] Each of the 24 sets of sentences provides a sentence frame that was used in one of the study lists, followed by two sentence frames that tested either the disconfirmed noun or the target noun previously associated with that study sentence. Cloze values of test sentences are based on the completion rates of sentences in the control condition.

Filler Sentences Used on Study Lists

	Terminal nouns	Age: Grade 2	Age: Grade 6	Age: College
1. Bugs Bunny likes to eat	carrots.	1.0	1.0	1.0
2. Rain, rain, go away. Come again another	day.	1.0	1.0	1.0
3. Apples grow on an apple	tree.	1.0	1.0	1.0
4. Hickory, Dickory, Dock! The mouse ran up the	clock.	1.0	1.0	1.0
5. The chicken laid an	egg.	.96	1.0	1.0
6. Butterflies fly by flapping their	wings.	1.0	1.0	1.0
7. He put a dollar into his piggy	bank.	1.0	1.0	1.0
8. We smell with our	nose.	1.0	1.0	1.0
9. A robin is a	bird.	1.0	1.0	1.0
10. A cow has four	legs.	.88	.79	.79
11. Open your mouth and stick out your	tongue.	1.0	1.0	1.0
12. I learned how to sing a new	song.	1.0	1.0	.96

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