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Age Preservation of the Syntactic Processor in Production

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Abstract

Two experiments are reported on the influence of cognitive aging on grammatical choice in language production. In both experiments, participants from two age-groups (young and old) produced sentences in a formulation task (V. Ferreira, 1996) that contrasted conditions allowing a choice between alternative sentence arrangements (i.e., double object or prepositional dative) or that permitted no choice (i.e., prepositional dative only). Experiment 1 showed that older adults were unable to formulate the alter native sentence arrangements with the same speed and fluency as young adults. Experiment 2 showed that cueing attention to one of the two object nouns to be included in the sentence resulted in the earlier expression of the cued noun in choice conditions, but with little evidence of a response time or dysfluency cost in the no-choice condition. As in Experiment 1, there were no substantive age differences in latencies or dysfluencies. These results support existing models for the mechanisms that choose between grammatical alternatives and bind phrases to available argument positions and provide evidence that older adults are not impaired in their use of these mechanisms.

Keywords

Cognitive aging; grammatical encoding; datives

INTRODUCTION

Assuming that the average speaker spends an average 45 min a day talking, at a rate of 2.5 words per second (Levelt & Meyer, 2000), then by the time a speaker has reached the age of 65, he or she has produced over 150 million words. By this time, it might be expected that elderly speakers are highly skilled at putting words together into sentences. However, there are a variety of findings in the cognitive aging literature that would suggest otherwise.

There is evidence from studies of single-word retrieval and naming, for example, that older adults are impaired. In naming tasks, older adults are less accurate at naming objects and actions (Nicholas, Obler, Albert, & Goodglass, 1985; Nicholas, Obler, Au, & Albert, 1997) and are slower (Thomas, Fozard, & Waugh, 1977). Older adults experience more tip-of-the-tongue states during lexical retrieval than do younger adults (Burke, MacKay, Worthley, & Wade, 1991; Maylor, 1990). In picture or scene description tasks, older adults take longer pauses while retrieving names and use more indefinite terms, suggesting retrieval difficulty (Cooper, 1990). Many studies have shown that older adults are less efficient at using selective attention

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and have increased difficulty with Stroop color-word interference (Cohen, Dustman, & Bradford, 1984; Comalli, Wapner, & Werner, 1962; Houx, Jolles, & Vreeling, 1993; Kieley & Hartley, 1997; Li & Bosman, 1996; Spieler, Balota, & Faust, 1996; but see Verhaeghen & de Meersman, 1998). All of this evidence suggests that elderly speakers should have more difficulty producing sentences than younger speakers.

Speaking requires more than the retrieval of single words, however. It requires speakers to choose between different grammatical constructions and to coordinate the timing of word retrieval with the assembly of a grammatical plan for phrases within a sentence (Bock & Levelt, 1994; Garrett, 1980; Levelt, 1989). To date, few experiments have been conducted to examine whether the observed age deficits in lexical selection and retrieval extend to the process of producing multiword utterances. The evidence that is available from studies of the spontaneous production of older adults, however, suggests that they may be impaired in full sentence formulation as well.

Kemper (1992) has suggested, for example, that older adults may produce sentences that are less syntactically complex than those of younger adults. Indeed, older adults have been shown to have deficits in working memory capacity (Carpenter, Miyake, & Just, 1994; Gick, Craik, & Morris, 1988; Kemper, 1988; Light & Anderson, 1985; Tun, Wingfield, & Stine, 1991). Kemper *et al.* have shown than older adults produce fewer syntactically complex sentences in a number of different types of language production tasks (e.g., sentence repetition, spontaneous speech, written production) and make more errors or are more dysfluent when they do attempt to produce them (Kemper, 1986, 1988; Kynette & Kemper, 1986). In addition, Kemper *et al.* linked these patterns to deficits in working memory. Kemper, Kynette, Rash, O'Brien, and Sprott (1989) found that forward and backward digit span were positively correlated with the number of left-branching constructions in oral or written production among a group of older adults. Recently, Kemper, Thompson, and Marquis (2001) showed a decline in the production of grammatically complex constructions from speech samples in a longitudinal study. Individual differences in digit span accounted for some of the variance in grammatical complexity in the study by Kemper et al. (2001). In general, there appears to be good evidence suggesting that older adults have difficulty processing sentences that make heavy demands on working memory.

Little experimental evidence is available concerning how older adults produce simple sentences that would not be expected to load working memory, however. A basic task for any speaker is to choose between alternative grammatical constructions to express a given message and to coordinate the retrieval of lexical items with the assembly of constituent structure. In the experiments reported below, we examined the performance of older adults in a sentence generation task that has been used in various forms in past research to examine grammatical choice in production (F. Ferreira, 1991, 1994; V. Ferreira, 1996). The key feature of this task is that subjects assemble sentences from words presented on a computer monitor, rather than select and retrieve words from memory as well as assemble them. In our version of this task, participants are presented with a subject-pronoun and a main verb (e.g., *I told*) on a computer monitor, followed by content words of a simple sentence presented all at once, but arranged in a random order. The task is to arrange the words into a sentence and produce it out loud. As in the example sentences (1) and (2) below, the main (dative) verb either allows multiple grammatical forms or is restricted in the type of construction that can be used. In addition, the words presented after the subject and verb are either two nouns (e.g., *manager, story*) or two nouns and a preposition (e.g., *manager, story, to*).

1. **a.** I told a story to the manager.

b. I told the manager a story.

2. **a.** I mentioned a story to the manager.

b. *I mentioned the manager a story.

When a preposition is not presented, participants have an option for the arrangement of the sentence when there is an alternating verb. For example, when an alternating verb such as *told* is presented without a preposition, then either a prepositional dative (PD) or a double object (DO) construction can be used, as in (1a) or (1b). When a nonalternating verb such as *mention* is presented, then only the prepositional dative option is available, as in (2a). When a preposition is present in the display, then the prepositional dative is the only option for either verb type. The latency to initiate the sentence and the rate of dysfluency during production are taken to indicate how quickly and efficiently subjects can arrange the sentence according to the grammatical options available. Past research has established that grammatical encoding proceeds more efficiently when speakers have more options to formulate an utterance, as in the case of (1a-b) above (V. Ferreira, 1996).

If the age deficits observed in past research on single-word production or in the spontaneous generation of more complex utterances extend to the processes involved in the construction of simple utterances, older adults would be expected to have difficulty coordinating the recognition of lexical items from the words presented on the screen with the construction of an utterance plan. In contrast, if the deficits observed in past research are largely confined to lexical selection and retrieval processes, older adults would not be expected to be impaired during performance of the present task, which only requires the timely assembly of words into phrases, but not the selection and retrieval of lexical items from memory.

EXPERIMENT 1

Experiment 1 uses the presence of a preposition in the display to restrict the options available to participants, along with the alternator and nonalternator verb contrast. Also, the participants were given a measure of speaking span (Daneman & Green, 1986) to provide additional evidence concerning the memory impairments of the older adults in this experiment.

Method

Participants—Forty-eight older adults and 48 younger adults completed Experiment 1. The older adults were residents from the East Lansing, Michigan community and were paid $8 for their participation. The younger participants were students from Michigan State University. The students received credit in introductory level psychology or statistics courses or were paid $5 per hour for their participation. Both the older and younger adults were solicited via ads in campus or community newspapers (for the paid participants). The average age of the older adults was 74.4 (SD = 4.8), and the average age of the younger adults was 21.6 (SD = 3.6). The older participants scored higher on the vocabulary test (highest possible: 40) [M_{Old} = 34.5, M_{Yng} = 30.0, $t(92) = 4.86$, $p < .001$], while the average education level (years) for the two groups was not significantly different (M_{Old} = 15.3, M_{Yng} = 14.9). All participants (with the exception of two younger adults) completed the Shipley vocabulary test (Shipley, 1940), and all were native English speakers. Both age-groups completed a measure of speaking span (Daneman, 1991; Daneman & Green, 1986) to assess whether the two age-groups had different working memory capacities for sentence production. The speaking span task required participants to temporarily hold a list of words in memory while formulating a different sentence for each word on the list. Participants were given 20 lists of words 2, 3, 4, 5, or 6 words in length (5 lists for each list length) for a total of 100 words. The speaking span measure is the total number of words for which participants could produce a sentence for each word. Older adults scored lower on the speaking span measure (highest possible: 100) than younger participants [M_{Old} = 51.4, M_{Yng} = 66.2, $t(92) = 8.01$, $p < .001$]. Note that we examined the correlations between a variety of measures from the experiment in relation to speaking span

(e.g., average RT, dysfluency rates), but none were strongly related to performance, independent of vocabulary score.

Apparatus—The sentence formulation task was presented and controlled using custom software (Clifton, 1988) on a CompuAdd 386SX IBM-compatible personal computer. The words presented in the task were displayed using a VGA monitor in 80 column mode from a distance of approximately 35–45 cm. Voice production latencies were recorded using a Shure microphone placed directly in front of the participant (at a distance of approximately 20 cm) connected to a Gerbrands G1341T voicekey. A CyberResearch CYRCTM-05 timing card, separate from the internal clock, was used to control the timing of the presentation of the materials and to record production latencies. Participants used a button on an external button box to advance trials. The experiment was recorded on tape for later transcription.

Materials and Design—Sentence frames were constructed and paired with alternator and nonalternator verbs, based on the materials from V. Ferreira (1996). Twenty-four pairs of alternator/nonalternator verbs (e.g., *told/mentioned*) were used and each pair was combined with two sentence frames (e.g., *excuse/to/manager* and *story/to/editor*). Each sentence frame accepted either verb of the pair to form a single item. Preposition-absent conditions were created by leaving the preposition out of the sentence frame. The sentence frames were organized into four groups of 12 sentence frames each. These four groups were rotated through the Verb Type X Prepositional Constraint conditions in a 4 × 4 Latin square. This design resulted in each participant seeing a specific item in only one condition, but all four experimental conditions across items. Thus each verb was presented only once per participant but each condition was seen 12 times per participant. In addition, acceptability ratings for sentences constructed using the materials for the production task were collected from both age-groups following the sentence span measure and the experimental production task. These ratings showed that both age-groups rated the DO versions of the nonalternator verb sentences as unacceptable and worse than PD sentences with the nonalternator verbs or either PD or DO versions of sentences with alternator verbs.

As in V. Ferreira (1996), 48 filler sentence frames were included among the experimental frames. These consisted of 36 frames with intransitive verbs taking prepositional phrase arguments and 12 frames that included verbs that could take noun phrases as arguments. All sentence frames were presented to each participant in randomized order with experimental and filler sentence frames intermixed. In addition to the 96 frames of the main task (48 experimental and 48 filler frames), 20 practice frames with nondative verbs were presented.

The design was a 2 × 2 × 2 mixed design with age as a between-participants factor and verb type and prepositional constraint as within-participants factors. Age had two levels: young and old. Verb type had two levels: alternator and nonalternator; and prepositional constraint had two levels: preposition present and preposition absent.

Procedure—Participants received a description of the experimental task and then completed a vocabulary test before beginning the experiment. They were given instructions to produce a single well-formed sentence in response to words presented on the computer monitor, using all the words that were presented on a given trial. Participants were also told that they could add words such as “the” or “my” to make the sentences grammatical. The sentences were to begin with the subject-pronoun (“I”) and a verb followed by additional words. Participants were told to silently read the subject and verb and not to initiate a sentence until the additional words appeared. Further, they were asked to produce the sentences as quickly as possible once the additional words were presented, incorporating each word, without making any mistakes or dysfluencies. Twenty practice trials were given, and if the participants made any mistakes, further explanation was provided. As soon as they initiated a trial, a blank screen was presented

for 250 milliseconds, followed by a fixation cross at the center of the screen which remained on the screen for 500 milliseconds. The cross was replaced by the subject-pronoun and the verb presented at the center of the screen. This display remained for 1500 milliseconds, replaced by a blank screen displayed for 250 milliseconds. Following the blank screen, either two or three additional words were presented. These words appeared simultaneously and randomly among three positions. If three words were presented, one word appeared at the center of the screen, another appeared two lines above the center, and the third appeared two lines below, so that each word was separated by one line. If two words were presented, they each could appear in any of the three positions with equal probability. Production latencies were recorded from the onset of the post-verbal words until the onset of the participant's response sentence.

Following the initiation of a response sentence, the words on the screen were replaced by a timing bar. The timing bar consisted of a series of dashes, starting at the top of the screen and continuing to the bottom, for a duration of 2000 milliseconds. The duration of this timing bar was 700 milliseconds longer than in V. Ferreira (1996) in order to accommodate the anticipated slower response times of the older adults. Once the timing bar reached the bottom of the screen, a 250-Hz tone sounded for 250 milliseconds. Participants were told to complete their sentence by the time the timing bar reached the bottom of the screen and the tone sounded. They were further told that the purpose of the timing bar was to encourage them to produce the sentence as quickly and as smoothly as possible, and that the best way to produce the sentence in this manner would be to plan what they intended to say before they initiated the sentence because the timing bar would not start until they started the sentence. Upon completion of the sentence, the experimenter recorded whether the voicekey had been set off by the participant's sentence or by an extraneous noise (e.g., lip smack or participant's tapping of the table), and the next trial began. No additional feedback concerning the deadline was provided. That is, participants were not reminded to speed up or slow down based on their performance relative to the deadline; instead, the deadline was used to encourage smoother sentence production.

Data Analysis—Analyses were conducted for the proportion of different sentence types produced, average dysfluency rates, and average response times. The sentences produced in the formulation task were classified into three categories: PD sentence, DO sentence, or other type of sentence. The other sentences category included fragments or complete sentences that did not correspond to either a DO or a PD construction. For example, a participant could have produced a construction such as *I carried groceries to help out the family*, instead of *I carried groceries for the family*, and this would be classified as other.

Dysfluency rates were calculated based on the proportion of sentences of a given type that were produced with some sort of difficulty. These were sentences produced with a hesitation, pause, repair, or other difficulty, and are reported for PD and DO sentences. Dysfluencies and errors were coded by the first author. In addition, all utterances of 10 participants were independently coded for dysfluencies by a research assistant naïve to the purposes of the present study. The classification of fluent versus dysfluent/error agreed on 89.9% of the utterances, with the majority of the disagreements occurring for utterance-internal pausing. Average response times were calculated using the time taken to initiate each sentence and were calculated using fluent and complete sentences only, using the data coded by the first author. The average response times include only observations in which subjects produced either DO or PD sentences (i.e., not others).

In addition, 1.8% of the response times were excluded because of failure of the voicekey to trigger or extraneous noises. One younger participant was excluded from the analysis in Experiment 1 and replaced because too few of the sentences obtained in the formulation task could be used. This was due to the addition of too many adjunct phrases, which resulted in too few DO and PD sentences for analysis of response time and dysfluency rate.

Results

Type of Sentence Produced—Table I shows the average proportion of DO, PD, and other sentence types produced in the formulation task. The table provides a summary of the relative distribution of the sentence types across the four experimental conditions. Also included in the table is the average proportion of DO sentences relative to the total number of DO and PD sentences produced [i.e., DO/(DO + PD)]. This proportion provides a measure of the relative frequency of DOs compared to PDs. All sentences that could be coded as PDs or DOs were included in this summary, including cases in which participants produced sentences that would be normally classified as ungrammatical. For example, a DO with a nonalternator verb, as in **I obtained my friends some tickets* was included as a DO. Thus, Table I shows whether participants produced DOs when the opportunity was available and whether they avoided producing them with nonalternator verbs. Two aspects of the sentence proportions were examined, in addition to any age differences: (1) the proportion of other sentence types as a function of type of verb and prepositional constraint, and (2) the relative proportion of DO sentences as a function of type of verb and prepositional constraint. The former analysis is intended to show whether the average proportions of the sentences of other types were roughly equivalent across conditions, whereas the latter analysis is designed to show whether the verb type and prepositional constraint variables had their intended effects. Participants were expected to produce DO sentences only with the alternator verbs and only when the preposition was not present in the display. Therefore the relative proportion of DOs should be substantially higher in this condition than in the rest of the conditions, in which the proportion of DO productions should be close to zero.

Considering first the proportion of sentences of other types, Table I shows that the average proportion of these sentences was lower in the alternator than in the nonalternator conditions and higher in the preposition-present than in the preposition-absent conditions. In particular, the alternator-no preposition condition has the lowest proportion of other sentences. This pattern is equivalent in the two age-groups. A mixed model ANOVA confirms this pattern, with significant main effects for verb type [F_1 (1,94) = 25.6, $p < .001$, $MSE = .014$; F_2(1,46) = 15.7, $p < .001$, $MSE = .012$], prepositional constraint (marginal by items) [F_1(1,94) = 4.36, $p < .05$, $MSE = .011$; F_2(1,46) = 3.29, $p = .08$, $MSE = .008$], and an interaction between verb type and prepositional constraint [F_1(1,94) = 5.49, $p < .05$, $MSE = .010$; F_2(1,46) = 5.37, $p < .05$, $MSE = .010$; F_2(1,46) = 5.37, $p < .05$, $MSE = .005$] This analysis shows that on some trials participants produced utterances other than a PD or DO, but this was less likely when there were more options available.

One potential concern is the lower proportion of DO sentences in comparison to the PD sentences in the condition with alternator verbs and no preposition. This pattern, which was also observed in V. Ferreira (1996), could (in principle) be due to an overall preference for the PD construction or to our use of a sample of verbs that are characteristically produced as PDs. Estimates of the frequencies of PD and DO forms obtained from an analysis of the Brown and London-Lund corpora by Herriman (1995), however, show that dative verbs like the ones used in the present study are not characteristically used only as prepositional datives. Using Herriman's estimates of the frequencies of the two types of construction, the average proportion of PDs for the verbs in the present study was .471, (SD_{PD} = .326), suggesting roughly equivalent usage of the two forms. This was also true when the analysis was restricted to verbs that were relatively frequent (i.e., with a frequency of more than 20 in Herriman's analysis across both the DO and PD forms): The average proportion of PD sentences was .561 (SD_{PD} = .233). Thus Herriman's (1995) frequency estimates do not suggest that there is a global preference for one form versus another or that the verbs used in the present study were biased to be used as PDs. An alternative explanation for the greater proportion of PDs is syntactic priming (Bock, 1986; Potter & Lombardi, 1998). As noted in V. Ferreira (1996), because more than half of the

sentences produced by participants in the present design were PDs, it is plausible to assume syntactic priming for this construction might have taken place on some of the trials.

Considering the relative proportion of DO sentences, the average proportion was greater with the alternator verbs when there was no preposition in the display compared to when there was a preposition or when the verb was a nonalternator. This was reflected in a planned orthogonal contrast between the alternator-no preposition condition and the other three conditions [$F_1(1,94) = 228.6$, $p < .001$, $MSE = .326$; $F_2(1,46) = 178.9$, $p = .001$, $MSE = .199$]. Also, there was a main effect of age for this comparison [$F_1(1,94) = 8.84$, $p = .004$, $MSE = .326$; $F_2(1,46) = 8.18$, $p = .006$, $MSE = .199$]; older adults had a lower proportion of DOs than younger adults in the alternator-no preposition condition [$t(48) = 2.62$, $p = .01$]. This analysis shows that, as expected, the relative proportion of DOs was higher in the condition with the alternator verb when there was no preposition in the display relative to the other three conditions and also that younger adults were slightly more likely to produce DOs in that case (i.e., when there was a grammatical option to do so).

Production Latencies—Figure 1 shows the production latencies for both age-groups based on average response times for fluent sentences that were produced as either DOs or PDs. The error bars in this and all other figures are standard errors calculated according to the recommendations made by Estes (1997). Average production latencies were longer in conditions with the preposition present and in conditions involving nonalternator verbs. In addition, Fig. 1 shows that the response times for older and younger participants are similar in pattern, and statistical analyses showed no significant age effects.

The account presented in V. Ferreira (1996) of performance on this task suggests that the average response time for the alternator verb-no preposition condition should be faster than any of the other three conditions because in that condition there are more options available to complete the sentence. Briefly, grammatical encoding proceeds using the first option compatible with the words to be included in the sentence, and with more options, there is a better chance that an option will be available. The data presented in Fig. 1 are consistent with this account, and a planned comparison between the alternator verb-no preposition condition versus the other three conditions confirmed this result [$F_1(1,94) = 17.5$, $p < .001$, $MSE = 491466$, $F_2(1,46) = 18.7$, $p < .001$, $MSE = 333372$]. Pairwise comparisons between conditions other than the alternator verb-preposition–absent condition demonstrated one significant effect: The comparison of the preposition-present versus preposition-absent conditions for the nonalternator verbs was significant by participants, with slower RTs in the preposition-present condition [$F_1(1,94) = 6.3$, $p < .01$, $MSE = 50684$]. None of the comparisons were significant by items.

In sum, these comparisons show that the sentences were produced more quickly when more options were available.

One potential methodological concern (also discussed in V. Ferreira, 1996) is that the alternator-preposition–absent condition is the only condition in which there are DO sentences averaged in with the PD sentences. This condition might be faster simply because the DO sentences did not require a preposition (and therefore are shorter) or because participants did not have to attend and incorporate the “to” presented on screen, for example. We conducted two additional analyses that suggest this is not the case, however. First, the average RTs for DO and PD sentences produced in the alternator-no preposition condition were compared. No significant differences were observed, and the average RTs for DO (1330 ms) and PD (1347 ms) sentences were numerically similar. Second, an analysis conducted on the average response times for just prepositional datives yielded a similar pattern of results as the above analysis: The comparison between the alternator verb-no preposition condition versus the other three

conditions was significant [$F_1(2,94) = 8.52$, $p < .001$, $MSE = 775039$, $F_2(2,46) = 6.6$, $p = .003$, $MSE = 375284$]. The comparison of the preposition-present versus preposition-absent conditions for the nonalternator verbs was significant by participants [$F_1(2,94) = 5.1$, p .008, $MSE = 60766$], but not by items. This pattern supports the suggestion that participants were faster in the alternator-no preposition condition because the available options allowed more flexible encoding, rather than a sentence length explanation.

Another potential methodological concern for the response time analysis is that alternator verbs like those used in the present study have a higher frequency of usage, as a group, than nonalternator verbs. To assess whether verb frequency is a possible explanation for the pattern of findings presented above, frequency estimates of the verbs were obtained from Francis and Kucera (1982) and compared for the two verb types. The alternator verbs had an average frequency of 332 ($SD_{ALT} = 393$), whereas the nonalternator verbs had a lower average frequency of 124 ($SD_{NON} = 144$), paired-samples [$t(24) = 2.36$, $p = .013$]. This difference was also significant using natural logarithms of the frequencies: paired-samples [$t(24) = 2.09$, $p = .023$]. An analysis of covariance on the average response times (from the items analysis) was conducted collapsed across sentence type produced, including only fluent sentences. The results from the earlier analysis did not change when verb frequency was entered as a covariate. Thus this analysis presents no evidence that verb frequency by itself can account for the faster response times for alternator verbs obtained in this experiment.

Dysfluency Rates—Figure 2 shows the proportion of dysfluent sentences in each condition by age-group. No substantive age differences appear to be present. The proportion of dysfluent sentences was lower when a preposition was absent in comparison to when it was present, and there were fewer dysfluencies in conditions with alternator verbs compared to nonalternator verbs.

As with the latency data, there were no interactions with age among the experimental conditions, or an age main effect. The V. Ferreira (1996) model predicts fewer dysfluencies in the alternator verb-no preposition condition relative to the other three conditions because in that condition there are more options available to complete a sentence. Figure 2 shows this pattern, and a planned comparison between the alternator verb-no preposition condition versus the other three conditions also provided support [$F_1(1,94) = 37.0$, $p < .001$, $MSE = .072$, $F_2(1,46) = 28.7$, $p < .001$, $MSE = .172$]. Pairwise comparisons between conditions other than the alternator verb-preposition absent condition showed variable patterns of statistical significance, because some of the comparisons were not significant by items, although some were significant by participants. In particular, the comparison between the alternator verb-preposition–present condition versus the nonalternator verb-preposition–present condition was significant by participants [$F_1(1,94) = 6.9$, $p < .01$, $MSE = .018$, and by items, $F_2(1,46) = 4.58$, $p < .05$, $MSE = .039$]. The comparison of the preposition-present versus preposition-absent conditions for the nonalternator verbs was significant by participants [$F_1(1,94) = 6.3$, $p < 0.01$, $MSE = 50684.4$] but not by items. Finally, the comparison between the alternator verb-preposition–present and nonalternator verb-preposition–absent conditions was not significant by participants or by items.

These results show that participants were less likely to produce dysfluencies in conditions in which more options were available, and that for displays where a preposition was present, participants were less likely to produce a dysfluency with the alternator verbs.

Discussion

The results of Experiment 1 show that in this paradigm, participants are faster and less dysfluency-prone when producing sentences with verbs that have an option for the grammatical arrangement of a sentence, relative to sentences with verbs that do not have such an option. In

addition, while the older adults in this sample were impaired on a measure of working memory (speaking span), age was not a determining factor in this experiment, because age did not enter into any substantive main effects or interactions with response time or production difficulty as measured by dysfluency rate. These results replicate earlier work by V. Ferreira (1996) and suggest that age does not have a substantial effect on the decision processes operating in language production to choose one grammatical alternative over another when options are available.

EXPERIMENT 2

During sentence assembly, speakers must coordinate the retrieval of words with the correct structural position of those words within a sentence frame. Because the time it takes to retrieve a lemma may vary, it is possible that there might be a mismatch between the timing of word retrieval and the availability of a position within a structural frame to accommodate the retrieved word (Kempen & Hoenkamp, 1987).

In Experiment 1, there was no explicit manipulation of the timing of word recognition before utterance onset. Because the arrangement of the words on the screen was random, the relative timing of the different words to be assembled in the sentence was probably also random. Speakers assembled sentences based on whichever words became available, and the results suggested that having more structural options available to accommodate the different retrieval times facilitated production latencies.

It is possible, therefore, that the reason no age deficits in sentence assembly were observed in Experiment 1 is that subjects were not presented with a mismatch between the timing of word recognition and the availability of structural options. If such mismatches are common in everyday language production, and older adults have difficulty managing such mismatches, then the results of Experiment 1 could suggest an uncharacteristically positive view of how older adults assemble sentences.

Experiment 2 tested whether the relative availability of words to be assembled in a sentence would influence how sentences are produced, using the same task as Experiment 1, with one modification. Based on past research showing that accessibility can influence the choice of grammatical form (Bock & Irwin, 1980; Bock & Warren, 1985), we expected that a cue to one of the lexical items presented on the screen would lead to the earlier accessibility of that term. In this experiment, participants formulated and produced sentences after viewing a subject-pronoun and verb as in Experiment 1, followed by two nouns, this time presented side by side rather than vertically arranged and with no prepositions in the display. The verbs in this experiment were also either alternators or nonalternators, but unlike Experiment 1, one of the two nouns that followed the verb was made more available (relative to the other noun) by cueing attention to the location in which it would appear. In particular, after the subject and verb were presented and before the display of the two nouns, a fixation cross appeared to the left of the center of the screen at the position where one of the two nouns would be presented. The nouns were then presented, and participants produced the sentence as in Experiment 1.

If the most accessible noun is expressed first, participants should be more likely to produce DOs when the indirect object is cued (and similarly for PDs when the direct object is cued). Thus, for a presentation sequence in which *I told*, *manager*, and *story* are presented, and the location of *manager* is cued before its presentation, participants should be more likely to produce the DO, *I told the manager the story*. For sequences in which the location of *story* is cued before its presentation, participants should be more likely to produce the PD, *I told a story to the manager*. This prediction only holds for the alternator verbs, because their syntactic arrangement can be flexibly arranged to accommodate either cueing condition. A different prediction holds for the nonalternator verbs because these verbs only have the option of the

prepositional dative form for expressing the two postverbal arguments. Specifically, conditions were compared in which the direct object noun was cued (e.g., *story* in *I mentioned a story to the manager*) versus a condition in which the indirect object noun was cued (e.g., *manager*). If, as might be expected, accessibility has a cost when there is no option to express it, there should be an increase in response time or dysfluency rate for the latter condition. Older adults might be expected to have more difficulty managing the mismatch of timing under these circumstances and have difficulty producing these sentences. This explicit manipulation of the timing of the lexical items to be assembled in the sentences is thus a stronger test of the hypothesis that older adults have difficulty with grammatical encoding independent of word selection and retrieval.

Method

Participants—Thirty-two undergraduate participants from Michigan State University and 32 older adults from the East Lansing community were recruited for this experiment. The participants were recruited for the experiment in the same way as Experiment 1, but none had participated in Experiment 1. The younger adults were given class credit for their participation, and the older adults (*M* age = 73) were paid ($8/h) for their participation. Participant characteristics such as years of education, vocabulary score, or speaking span were not collected for this experiment and can be presumed to be comparable to the those of Experiment 1 participants because both experiments sampled from the same participant pools. The data from three participants were lost because of a faulty tape cassette and these participants were replaced.

Materials and Design—The same materials and equipment that were used in Experiment 1 were used in Experiment 2, except that all prepositions were removed from the sentence frames used in Experiment 1, and a different counterbalancing scheme was used. The 24 pairs of alternator/nonalternator verbs used in Experiment 1 were each combined with a single sentence frame (from Experiment 1) to provide 48 experimental sentences. In half of the 48 experimental sentences, one noun in the sentence frame was cued (see below), and in the other half the other noun was cued. This was counterbalanced across participants so that half of the participants saw one of the nouns cued, and half saw the other, for each verb. In addition to the 48 experimental sentences, the same 48 filler sentences as in Experiment 1 were used.

The design was a 2 × 2 × 2 mixed design with age as a between-participants factor and verb type and cue type as within-participants factors. Age had two levels: young and old. Verb type had two levels: alternator and nonalternator. Cue type had two levels: either the cued noun was consistent with a prepositional dative, or the cued noun was consistent with a double object.

Procedure—Except as specified, the procedure was like that of Experiment 1. Immediately following the offset of the subject-pronoun and verb, a small white fixation cross was displayed for 500 milliseconds at a location to the left of the center of the screen. This location corresponded to the center of the leftmost of the two postverbal nouns, which were displayed immediately following the offset of the fixation cross. This fixation cross was intended to cue the participant's attention to the location of the leftmost of two nouns that followed. The postverbal nouns were presented side by side to encourage participants to focus attention on the left side.

Data Analysis—The data were analyzed in the same manner as in Experiment 1. Each sentence was transcribed from tape and coded for its form (i.e., DO, PD, or other) and whether a dysfluency occurred. As in Experiment 1, sentences were coded as dysfluent if they were produced with hesitations, pauses, stuttering, or repairs, and the utterances from 10 participants were independently coded for dysfluencies by an separate coder for comparison purposes. The

classifications of the sentences agreed on 87.5% of the utterances. The sentences coded by the first author were used in the analysis. Observations with response times greater than 4 seconds were excluded from the analysis. In total, three observations (<1%) were excluded based on this 4-second cutoff.

Results

The results will be presented for the frequency of the different sentence types that participants produced in the four cueing X verb type conditions, their average response time, and their dysfluency rate data. As in Experiment 1, error bars on the figures correspond to standard errors of the mean.

Type of Sentence Produced—The bottom half of Table II shows the average proportion of DO, PD, and other sentence types produced for older and younger adults. As in Experiment 1, these data were analyzed in terms of the proportion of sentences of other types and also in terms of the average proportions of DOs produced relative to the total proportion of DOs and PDs. The latter analysis is intended to show whether the cue type manipulation was effective (i.e., the average proportion of DOs should be higher when DOs are cued, but only with verbs that alternate).

Considering first the proportion of sentences of other types, it can be seen that the average proportion of other sentences was relatively higher with nonalternator verbs, especially when the PD was cued. There were significant main effects for verb type [$F_1(1,62) = 55.57$, $p < .001$, $MSE = .010$; $F_2(1,46) = 12.65$, $p < .001$, $MSE = .033$; cue type, $F_1(1,62) = 11.5$, $p < .001$, $MSE = .012$; $F_2(1,46) = 12.48$, $p < .001$, $MSE = .007$] and an interaction between verb type and cue type [$F_1(1,62) = 34.2$, $p < .001$, $MSE = .011$; $F_2(1,46) = 37.7$, $p < .001$, $MSE = .007$]. There were no main effects of age, nor did age enter into any interactions. Post-hoct tests confirmed that the average proportion of other sentences was higher with the nonalternator verb when the cue was for the PD ($M = .236$) compared to the DO ($M = .116$) [$t(63) = 4.9$, $p < .001$] and conversely, the average proportion of other sentences was higher with the alternator verb when the cue was for the DO ($M = .103$) compared to the PD ($M = .070$) [$t(63) = 2.98$, $p < .01$]. The small difference between the alternator verb ($M = .103$) and the nonalternator verb ($M = .116$) when the DO was cued was not statistically significant. This analysis shows that in comparison to the remaining conditions, participants were slightly more likely to produce sentences of other types when they had to form a sentence with a nonalternator verb, especially when a PD was cued.

This last result is somewhat counterintuitive, because it might be expected that participants would be more likely to produce PDs in this case, rather than other types of sentences. The other sentences that participants produced were a variety of forms. In some cases, participants used possessive forms of the nouns, such as *I described an actor's script*, or *I heated my daughter's dinner*, and in other cases participants used adjectival forms, such as *I suggested an executive solution*. In the case of the use of these forms, it appears that participants initially understood the verb monotransitively (e.g., *I described the script*, or *I heated the dinner*), rather than ditransitively. This is not implausible, because they were cued with the noun that fit the monotransitive syntactic option (e.g., *I described* … script …), and the other noun could be understood as a possessor because it was animate or in other cases as an adjectival modifier. This would account for the greater proportion of others with the nonalternator verbs. A natural question to ask is why this would not apply in the case of the alternator verbs, which did not have the greater proportion of other sentences. Although there is no simple explanation for this, it could be that with the other grammatical option that the alternator verbs provide, participants are less likely to come up with the monotransitive interpretation. That is, with either the PD or DO options available, participants were less likely to take the monotransitive

option. Also, note that the verbs used in the alternator and the nonalternator conditions were different, so it could be that the nonalternator verbs used in the present study are more likely to be used monotransitively. Note, however, that not all of the other sentences were possessive or adjectival modifiers, so this account remains tentative.

Considering the relative proportion of DO sentences, the average proportion of DOs was greater when the DO was cued, but only with the alternator verb, reflected in an interaction of cue type and verb type [$F_1(1,62) = 134.1$, $p > .001$, $MSE = .057$; $F_2(1,46) = 318.7$, $p > .001$, $MSE = .016$]. In addition, there were main effects for verb type [$F_1(1,62) = 345.9$, $p < .001$, $MSE = .014$; $F_2(1,46) = 226.7$, $p > .001$, $MSE = .017$] and cue type [$F_1(1,62) = 129.9$, $p > .001$, $MSE = .014$; $F_2(1,46) = 172.2$, $p > .001$, $MSE = .009$]. There was no main effect of age, and age did not enter into any interactions. This analysis shows that cueing one of the postverbal nouns consistent with a DO or consistent with a PD resulted in a higher average proportion of those types of sentences, but only when the grammatical option was available.

Response Times—In the two alternator verb conditions, participants produced both DOs and PDs, whereas in the nonalternator conditions, they produced PDs almost exclusively. The response time data will therefore be analyzed two ways. First, disregarding the type of sentence that was produced, and second, with respect to whether the sentences were produced as prepositional datives or as double objects.

Figure 3 shows the average response time to initiate the sentences that were produced fluently (regardless of whether the sentence was produced as a prepositional dative or a double object). The only significant pattern is that participants were faster to produce sentences with alternator verbs ($M = 1129$) compared to sentences with nonalternator verbs ($M = 1195$) [$F_1(1,62) = 13.5$, $p > .001$, $MSE = 17856$ by participants; and $F_2(1,46) = 12.8$, $p > .001$, $MSE = 26425$ by items]. No other main effects or interactions were significant. This result is partially consistent with the accessibility hypothesis. Participants mainly produced sentences that were consistent with the cue in the alternator verb conditions, and the above RT result suggests that they were faster to do so. However, participants should have been just as fast to produce a PD when cued to produce a PD in the nonalternator condition as to produce a PD in the alternator condition when cued to do so. The data offer no support for this interaction pattern.

An analysis of the RT data restricted to cases in which subjects produced just prepositional datives yielded largely similar results. Participants were faster to produce sentences with alternator verbs (M = 1323) compared to nonalternator verbs (M = 1499). This main effect was significant by participants [$F_1(1,11) = 15.52$, $p = .002$, $MSE = 24099$] but not by items [$F_2(1,17) = .73$, $p = .405$, $MSE = 77660$], and there were no other main effects or interactions. Note, however, that not all participants produced PDs in all conditions, so this analysis concerns the 12 participants and the 18 items for which there were at least two observations per cell.

Thus an analysis of the average response times in Experiment 2 shows that participants were faster to produce sentences with alternator verbs, compared to sentences with nonalternator verbs. Also, with nonalternator verbs, there is no evidence that participants were slower when producing sentences for which a mismatching cue had been presented, compared to the case in which the cue matched the type of sentence they produced. Finally, no age differences were observed. In particular, older adults were not slower to start their utterances.

Dysfluency Rates—Figure 4 shows the average proportion of the sentences that were produced with dysfluency for the older and younger adults in Experiment 2 (regardless of which sentence type was produced). It shows that both older and younger adults tended to have higher average rates of dysfluency when producing sentences with the nonalternator verbs relative to the alternator verbs. This main effect of verb type was significant by participants [$F_1(1,62) =$

41.9, $p > .001$, $MSE = .011$] and by items [$F_2(1,46) = 21.3$, $p > .001$, $MSE = .017$]. No main effects of age or type of cue were observed, or any interactions, although the interaction of verb type with type of cue was marginally significant by participants [$F_1(1,62) = 2.89$, $p > .10$, $MSE = .013$] and by items [$F_2(1,46) = 3.43$, $p > .07$, $MSE = .008$].

Dysfluency rates can also be compared for sentences that were consistent with the cued structure versus sentences that were not consistent. However, not all participants produced both DOs and PD sentences in the conditions for which the DO was possible (i.e., some only produced PDs, others only produced DOs). In particular, there were too few observations with utterances with the alternator verbs that mismatched the cue in form to provide a meaningful dysfluency analysis for the alternator verbs. Therefore only the nonalternator verb condition is informative, because participants produced a PD with those verbs in most cases. The average dysfluency rates for the nonalternator verb condition were approximately equivalent for the two age-groups ($M_{Old} = .207$, $M_{Young} = .225$), but paradoxically, participants were slightly more fluent in producing sentences when cued with the noun consistent with the DO ($M = .194$), than when cued with the noun consistent with the PD ($M = .238$). This main effect of cue type was marginally significant both by participants [$F_1(1,62) = 2.98$, $p = .09$, $MSE = .021$] and by items [$F_2(1,46) = 3.35$, $p < .07$, $MSE = .011$].

In sum, the analysis of dysfluency rates shows that participants were more dysfluent when producing sentences with the nonalternator verbs compared to the alternator verbs. However, participants were no more dysfluent (and in fact numerically less dysfluent) when producing sentences for which a mismatching cue had been presented, compared to the case in which the cue matched the type of sentence they produced, suggesting that the cued availability of a noun that could not be incorporated into a sentence did not impose a cost for its production.

Discussion

The results from Experiment 2 show that the relative accessibility of a word or concept can influence the ultimate structural form of a sentence. Words that were cued by a fixation cross were more likely to be mentioned in an earlier structural position, relative to the noncued word for sentences with alternator verbs, which provide an option for how to arrange the sentence. These results can be explained if it is assumed that the relative activation of one word over another led to the grammatical encoding of the first available option, in agreement with an incremental model of production. In addition, the performance of older and younger adults in the present study was largely similar in pattern.

Although the relative activation of a word influenced the final form of the sentence that was produced, it does not appear to be costly for a word to be higher in activation even if it cannot be immediately structured into the sentence to be produced. The average response times and dysfluency rates for producing sentences with nonalternator verbs (which have only the PD structure option) were equivalent for the two cueing conditions. This suggests that activating a word that cannot be immediately incorporated does not result in competition for that noun to be incorporated into an incorrect structural position. In addition, the performance of the older adults, because they did not show a competition effect (slower average RTs or higher dysfluency rates) for the mismatching cues, provides good evidence that older adults are not impaired in their ability of assemble grammatical structures.

GENERAL DISCUSSION

The results of the two experiments reported here suggest that speakers can use grammatical options to accommodate varying rates of lexical retrieval to more efficiently assemble words into grammatical structures. Older adults appear to have little difficulty with this assembly process, suggesting that the deficits observed in the past literature on language production in

the elderly may be confined to lexical selection and retrieval of single words, rather than the choice and assembly of grammatical constituents.

A simple interpretation of the similar pattern of performance for the older and younger adults is that similar processes are at work in both age-groups. Also, it is noteworthy that older adults were not significantly slower than the younger adults, unlike most studies of cognitive performance in the elderly (e.g., Salthouse, 1996). Importantly, it appears that grammatical assembly processes do not decline to the same extent as other aspects of grammatical processing (e.g., such as age-related increases in difficulty with embedded sentences that load working memory; e.g., Kemper, 1986; Kemper et al., 2001). This finding also supports other suggestions in the literature (e.g., Tun & Wingfield, 1993; Wingfield, 1999) that some aspects of language use, in this case choice during grammatical encoding, resist the decline typically observed with age.

The experiments reported here also support the claim that language production operates incrementally so that alternative configurations of grammatical structure can accommodate varying levels of word or concept availability. Experiment 1 showed that sentences can be produced more quickly, and with fewer dysfluencies, if there are more grammatical options available. Participants from both age-groups produced sentences more easily when there were more syntactic options available, providing converging support for the earlier results of V. Ferreira (1996). This supports the view that greater syntactic flexibility allows the formulation system to accommodate variation in the activation of potential arguments, permitting the most highly active arguments to be built into the structural plan of the sentence first. This characteristic of incremental production implies that in grammatical encoding situations in which more than one structure is possible, sentence production will proceed more quickly and/or with fewer errors in comparison with situations in which fewer options are available. Surprisingly, Experiment 2 showed that whereas the greater accessibility of a term to be included in a sentence leads to the encoding of that term in an earlier structural position, there is little cost associated with the greater activation of a term that is not appropriate for the immediately available position. Speakers appear to be able to efficiently manage the variable availability of different lexical items so that they eventually obtain their correct structural positions. Even in the face of this variability, older adults manage to assemble grammatical structures as efficiently as young adults. An interesting direction to pursue in future work might be to modify the present experimental technique to examine other aspects of grammatical encoding in the two age-groups, including, for example, structural choice preferences that are plausibly related to heavy demands on working memory.

REFERENCES

Bock JK. Syntactic persistence in language production. Cognitive Psychology 1986;18:355–387.

Bock JK, Irwin DE. Syntactic effects of information availability in sentence production. Journal of Verbal Learning and Verbal Behavior 1980;19:467–484.

Bock, JK.; Levelt, WJM. Language production: Grammatical encoding. In: Gernsbacher, MA., editor. Handbook of psycholinguistics. Academic Press; San Diego CA: 1994.

Bock JK, Warren RK. Conceptual accessibility and syntactic structure in sentence formulation. Cognition 1985;21:47–67. [PubMed: 4075761]

Burke DM, MacKay DG, Worthley JS, Wade E. On the tip of the tongue: What causes word finding failures in young and older adults. Journal of Memory and Language 1991;30:542–579.

Carpenter, PA.; Miyake, A.; Just, MA. Working memory constraints in comprehension: Evidence from individual differences, aphasia, and aging. In: Gernsbacher, M., editor. Handbook of psycholinguistics. Academic Press; San Diego, CA: 1994.

Clifton, CE. PC-Experiment [computer program]. Author; Massachusetts: 1988.

Cohen NC, Dustman RE, Bradford DC. Age-related decrements in Stroop color test performance. Journal of Clinical Psychology 1984;40:1244–1250. [PubMed: 6490922]

Comalli PE, Wapner S, Werner H. Interference effects in childhood, adulthood, and aging. Journal of Genetic Psychology 1962;100:47–53. [PubMed: 13880724]

Cooper PV. Discourse production and normal aging: Performance on oral picture description tasks. Journal of Gerontology: Psychological Sciences 1990;45:210–214.

Daneman M. Working memory as a predictor of verbal fluency. Journal of Psycholinguistic Research 1991;20(6):445–464.

Daneman M, Green I. Individual differences in comprehending and producing words in context. Journal of Memory and Language 1986;25:1–18.

Estes WK. On the communication of information by displays of standard errors and confidence intervals. Psychonomic Bulletin & Review 1997;4:330–341.

Ferreira F. Effects of length and syntactic complexity on initiation times for prepared utterances. Journal of Memory and Language 1991;30:210–233.

Ferreira F. Choice of passive voice is affected by verb type and animacy. Journal of Memory and Language 1994;33:715–736.

Ferreira VS. Is it better to give than to donate? Syntactic flexibility in language production. Journal of Memory and Language 1996;35:724–755.

Francis, WN.; Kucera, H. Frequency analysis of English usage: Lexicon and grammar. Houghton Mifflin; Boston, MA: 1982.

Garrett, MF. Levels of processing in sentence production. In: Butterworth, B., editor. Language production. 1. Academic Press; London: 1980. p. 177-220.

Gick ML, Craik FIM, Morris RG. Task complexity and age differences in working memory. Memory and Cognition 1988;16:353–361.

Herriman, J. The indirect object in present-day English. Distributed by Acta Universities Gothoburgensis; Göteburg, Sweden: 1995. Doctoral dissertation, University of Gothenburg

Houx PJ, Jolles J, Vreeling FW. Stroop interference: Aging effects assessed with the Stroop Color-Word Test. Experimental Aging Research 1993;19:209–224. [PubMed: 8223823]

Kempen G, Hoenkamp E. An incremental procedural grammar for sentence formulation. Cognitive Science 1987;11:201–258.

Kemper S. Imitation of complex syntactic constructions by elderly adults. Applied Psycholinguistics 1986;7:277–287.

Kemper, S. Geriatric psycholinguistics. In: Light, LL.; Burke, DM., editors. Language memory, and aging. Cambridge University Press; New York: 1988. p. 58-76.

Kemper, S. Language and aging. In: Craik, FIM.; Salthouse, TA., editors. The handbook of aging and cognition. Erlbaum; Hillsdale, NJ: 1992. p. 213-270.

Kemper S, Kynette D, Rash S, O'Brien K, Sprott R. Life-span changes to adults' language: Effects of memory and genre. Applied Psycholinguistics 1989;10:49–66.

Kemper S, Thompson M, Marquis J. Longitudinal change in language production: Effects of aging and dementia on grammatical complexity and propositional content. Psychology and Aging 2001;16:600–614. [PubMed: 11766915]

Kieley JM, Hartley AA. Age-related equivalence of identity suppression in the Stroop color-word task. Psychology and Aging 1997;12:22–29. [PubMed: 9100265]

Kynette D, Kemper S. Aging and the loss of grammatical forms: A cross-sectional study of language performance. Language and Communication 1986;6:65–72.

Levelt, WJM. Speaking: From intention to articulation. MIT Press; Cambridge, MA: 1989.

Levelt WJM, Meyer AS. Word for word: Multiple lexical access in speech production. European Journal of Cognitive Psychology 2000;12:433–452.

Li KZ, Bosman EA. Age differences in Stroop-like interference as a function of semantic relatedness. Aging, Neuropsychology, and Cognition 1996;3:272–284.

Light LL, Anderson PA. Working memory capacity, age, and memory for discourse. Journal of Gerontology 1985;40:737–474. [PubMed: 4056330]

Maylor E. Recognizing and naming faces: Aging, memory retrieval, and the tip of the tongue state. Journal of Gerontology: Psychological Sciences 1990;45:215–226.

Nicholas, M.; Barth, C.; Obler, LK.; Au, R.; Albert, ML. Naming in normal aging and dementia of the Alzheimer's type. In: Goodglass, H.; Wingfield, A., editors. Anomia: Neuroanatomical and cognitive correlates. Academic Press; San Diego, CA: 1997. p. 166-188.

Nicholas M, Obler LK, Albert ML, Goodglass H. Lexical retrieval in healthy aging. Cortex 1985;21:595–606. [PubMed: 4092486]

Potter MC, Lombardi L. Syntactic priming in immediate recall of sentences. Journal of Memory and Language 1998;38:265–282.

Salthouse, T. A theory of cognitive aging. North-Holland; Amsterdam: 1985.

Salthouse T. The processing speed theory of adult age differences in cognition. Psychological Review 1996;103:403–428. [PubMed: 8759042]

Shipley WC. A self-administered scale for measuring intellectual impairment and deterioration. Journal of Psychology 1940;9:371–377.

Spieler DH, Balota DA, Faust ME. Stroop performance in normal older adults and individuals with senile dementia of the Alzheimer's type. Journal of Experimental Psychology: Human Perception and Performance 1996;22:461–479. [PubMed: 8934854]

Thomas J, Fozard J, Waugh NC. Age-related differences in naming latency. American Journal of Psychology 1977;90:499–509. [PubMed: 931028]

Tun, PA.; Wingfield, A. Is speech special? Perception and recall of spoken language in complex environments. In: Cerelia, J.; Rybash, J.; Hoyer, W.; Commons, ML., editors. Adult information processing: Limits on loss. Academic Press; San Diego, CA: 1993. p. 425-457.

Tun PA, Wingfield A, Stine EAL. Speech-processing capacity in younger and older adults: A dual-task study. Psychology and Aging 1991;6:3–9. [PubMed: 2029365]

Verhaeghen P, De Meersman L. Aging and the Stroop effect: A meta-analysis. Psychology and Aging 1998;13:120–126. [PubMed: 9533194]

Wingfield, A. Comprehending spoken questions: Effects of cognitive and sensory change in adult aging. In: Shwarz, N.; Park, D.; Knuper, B.; Sudman, S., editors. Cognition, aging, and self-reports. Taylor & Francis; Ann Arbor: 1999. p. 201-229.

Fig. 1.
Average production latency (ms) as a function of verb type and prepositional constraint, Experiment 1.

Fig. 2.
Proportion of sentences produced with a dysfluency as a function of verb type and prepositional constraint, Experiment 1.

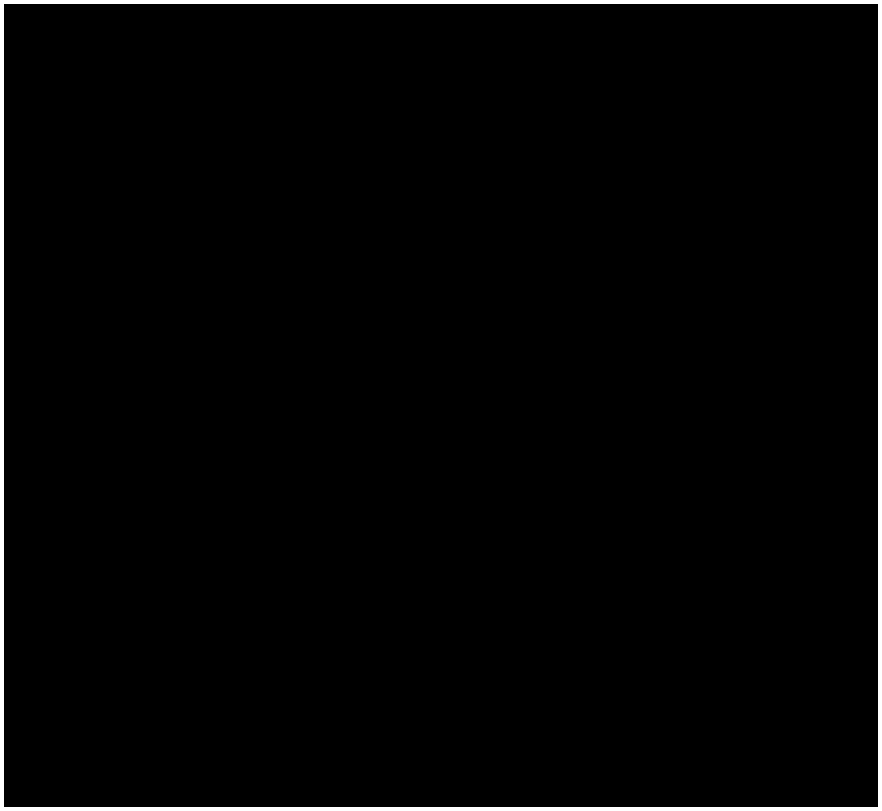

Fig. 3.
Average production latency (ms) as a function of verb type and cue type, Experiment 2.

Fig. 4.
Proportion of sentences produced with a dysfluency as function of verb type and cue type, Experiment 2.

Table I

Average Proportions of the Different Sentence Types in Experiment 1

	Age	Old				Young			
	Sentence type	**DO**	**PD**	**Other**	**Prop DO**	**DO**	**PD**	**Other**	**Prop DO**
Experiment 1									
Verb									
	Alternator								
Prep.	Present	0.06	0.78	0.16	.06	0.04	0.81	0.15	.05
Const.	Absent	0.24	0.66	0.11	.27	0.33	0.56	0.11	.38
	Nonalternator								
	Present	0.00	0.81	0.19	.00	0.01	0.80	0.19	.02
	Absent	0.03	0.79	0.18	.03	0.05	0.74	0.20	.06

Note: Prep. Const., prepositional constraint; PD, prepositional dative; DO, double object; Prop DO, proportion of DO/(sum of the proportions of DO and PD).

Table II

Average Proportions of the Different Sentence Types in Experiment 2

	Age	Old				Young			
	Sentence type	**DO**	**PD**	**Other**	**Prop DO**	**DO**	**PD**	**Other**	**Prop DO**
Experiment 2 *Verb*									
	Alternator								
Cue	PD	0.01	0.87	0.12	.01	0.02	0.86	0.11	.03
	DO	0.58	0.34	0.09	.64	0.56	0.32	0.12	.64
	Nonalternator								
	PD	0.17	0.59	0.24	.24	0.11	0.66	0.23	.15
	DO	0.11	0.82	0.06	.12	0.11	0.86	0.03	.12

Note: Prep. Const., prepositional constraint; PD, prepositional dative; DO, double object; Prop DO, proportion of DO/(sum of the proportions of DO and PD). For the variable Cue, DO corresponds to a condition in which the noun that was cued could have corresponded to the indirect object (first-mentioned noun) of the double object construction, and likewise for PD could have served as the direct object for the prepositional dative.