The Influence of Syntactic and Semantic Context on Word-monitoring Latencies in Normal Aging

Influences du contexte syntaxique et sémantique sur les temps de latence de la reconnaissance des mots au cours du vieillissement normal

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Abstract

This study explored the influences of syntactic and semantic context on on-line word recognition in normal younger and older adults. Ten subjects in each of four age groups (20s, 60s, 70s, 80s) participated in a word-monitoring task in which the stimuli were syntactically and semantically normal, syntactically normal but semantically anomalous, and syntactically and semantically anomalous (random word order) strings. The purpose of the task was to determine whether, relative to younger adults, older subjects would demonstrate an increased reliance on sentential contextual cues in on-line linguistic processing. Results revealed that, regardless of age, all subjects' word-monitoring latencies were comparably influenced by semantic and syntactic context. The findings are discussed in relation to theories of cognitive and linguistic decline in normal aging.

Résumé

Cette étude examine les influences du contexte syntaxique et sémantique sur la reconnaissance des mots en direct chez de jeunes adultes et des adultes plus âgés normaux. Dix sujets dans chacun des quatre groupes d'âge (20-29, 60-69, 70-79 et 80-89 ans) ont participé à un exercice de reconnaissance des mots, dans lequel les stimuli étaient des phrases syntaxiquement et sémantiquement correctes, des phrases syntaxiquement correctes mais sémantiquement incorrectes, et des phrases syntaxiquement et sémantiquement incorrectes (mots sans aucun ordre). Cet exercice avait pour but de déterminer si, par rapport aux jeunes sujets, les sujets plus âgés se fiaient davantage au contexte des phrases pour le traitement linguistique en direct. D'après les résultats, les temps de latence de la reconnaissance pour tous les sujets, quel que soit leur âge, ont été influencés de la même façon par le contexte syntaxique et sémantique. On analyse les conclusions en fonction de certaines théories du déclin cognitif et linguistique au cours du vieillissement normal.

Advancing age has been associated with declines in cognitive capacity (Zacks & Hasher, 1988), as well as in speed of processing (Cohen, 1988; Salthouse, 1988). These age-related changes have been attributed to limitations in working memory in terms of either storage capacity or processing functions; that is, tasks that place greater demands on working memory show the greatest performance decrements in older subjects (Kemper, 1988; Light & Albertson, 1988). How this decline in functioning interacts with linguistic processing is a question of great interest. It has been hypothesized that the age-related memory limitations may be partially offset by the availability of context, perhaps leading older adults to make greater use of contextual cues (Cohen & Faulkner, 1983). Thus, older adults may be more dependent on context than are younger adults. Evidence for an increased reliance on contextual information in older subjects has come from a variety of sources, although the issue is not without controversy (see Cohen, 1988; Light & Albertson, 1988, for discussion).

Of particular interest to the present investigation are studies that have concentrated on the use of context by older individuals during sentence processing. For example, Cohen and Faulkner (1983) explored the role of semantic sentential context on visual word recognition using a lexical decision paradigm. Younger and older subjects were presented with letter strings preceded by a sentence context of either high or low predictability or by a null context in the form of a string of Xs. The two subject groups exhibited shorter lexical decision latencies to the target words following both types of sentence context relative to the null context. In addition, the contextual facilitation effects for stimuli that were highly predictive of the target word were equivalent in both younger and older subjects. For target words that were preceded by contexts of low predictability, however, the older subjects' reaction times were facilitated to a greater extent than were those of the younger subjects. The authors concluded that the older subjects relied on context as a compensatory device when the context was of low predictability.

In contrast to these findings, however, Madden (1986) reported that younger and older adults were equally influenced by semantic context in a similar task. In this study, visual lexical decision latencies were obtained to words presented in sentence contexts that were semantically congruous, incongruous, or neutral relative to the target words.

Reaction times were facilitated to the same extent for both younger and older subjects by the presence of congruous contexts relative to neutral and incongruous contexts. Madden (1986) concluded that the older individuals were equal to the younger subjects in their use of semantic context in on-line word recognition.

As with the investigations of semantic context, results of experiments examining the role of syntactic context during sentence processing in normal aging present a mixed picture. Wingfield, Poon, Lombardi, and Lowe (1985) conducted an auditorily presented recall task using stimuli that were normal strings, semantically anomalous but grammatical strings, and random word order strings (cf. Marks & Miller, 1964; Marslen-Wilson & Tyler, 1980; Miller & Isard, 1963). Further, they presented the stimuli to subjects at several different rates of speech. Results revealed that increased speaking rate had little effect on recall for normal strings in either younger or older subjects; however, at fast rates of speech, the older subjects were able to recall fewer words from the anomalous and random strings. Wingfield et al. (1985) concluded that the older subjects used the contextual information in the normal strings to overcome the effects of increased speaking rate. In the anomalous and random conditions, little or no contextual support was provided and the increases in speaking rate impaired recall performance. In contrast to the older subjects, the younger subjects did not demonstrate as striking a difference between performance in the normal as compared to the anomalous and random string conditions, suggesting that they were less dependent on the contextual information. Wingfield et al. (1985) attributed the age-related differences in performance to limitations in speed of processing in older individuals.

By contrast, in an experiment utilizing similar types of stimuli, Holtzman, Familitant, Deptula, and Hoyer (1986) concluded that older individuals did not benefit any more than did younger subjects from syntactic contextual support. Holtzman et al. (1986) employed a recall task in which younger and older subjects were presented with syntactically appropriate and random word order strings at a slower than normal rate of speech, as well as at the subjects' speech reception thresholds. Although the older subjects' recall performance was poorer overall relative to the younger subjects, no differences across age groups were found in the amount of improvement in recall scores provided by the syntactically appropriate context as compared to the random word order context.

Thus, previous research has presented somewhat conflicting evidence regarding the role of sentential context cues for older individuals. In addition, the tasks and modes of presentation used in these studies differed; in particular, the studies that investigated semantic context alone employed on-line tasks with visual targets, while the studies that explored syntactic cues used off-line recall tasks of auditorily presented stimuli. The extent to which on-line auditory sentence processing is affected by both syntactic and semantic context in normal aging remains to be determined.

The current study was conducted in an attempt to further examine the effects of syntactic and semantic context on word recognition in younger and older adults. Using a word-monitoring paradigm, as introduced by Marslen-Wilson and Tyler (1980), we planned to explore whether older individuals would exhibit increased context dependency in auditory on-line linguistic processing (Cohen & Faulkner, 1983). In their study, Marslen-Wilson and Tyler (1980) measured word-monitoring latencies in normal, anomalous, and random word order strings in young subjects. Their results revealed that response times were fastest in the normal strings due to the support of semantic and syntactic cues. In addition, latencies to target words occurring toward the ends of the normal and anomalous strings were faster than response times to words occurring early in the stimulus sentences, due to the presence of syntactic cues. Following Marslen-Wilson and Tyler (1980), we hypothesized that both younger and older subjects should benefit from contextual information such that word-monitoring latencies should be shorter in normal as compared to semantically anomalous and random word order strings. Further, in both anomalous and normal sentences, the build-up of syntactic information should facilitate reaction times to later-occurring target words as compared to targets that appear early in the stimuli (Marslen-Wilson & Tyler, 1980). The goal of the present investigation, then, was to determine whether older subjects would demonstrate differentially greater dependence on the syntactic or semantic contextual information as compared to younger adult subjects in a reaction time task exploring on-line auditory sentence processing.

Methods

Subjects

Ten subjects were tested in each of the age decades 20-29, 60-69, 70-79, and 80-89, for a total of 40 participants in this study. All of the subjects were community dwelling, native speakers of English, and none had any known hearing loss or neurological impairment. Years of education were relatively high for all groups, ranging from 9 to 20 years within the groups, with means of 14.3, 13.7, 13.0, and 12.4 years for subjects in their 20s, 60s, 70s, and 80s, respectively. All participants except those in the youngest group were administered a version of the Mini-Mental Status Exam (MMS) to rule out possible dementia. No subject scored lower than 26/32 on the MMS. Neither years of education nor MMS

Table 1. Background information on subjects.

GROUP		SEX	AGE	EDUCATION (YRS)	HEALTH STATUS	MMS* (max.32)
20s	2N1	F	22	13	Good	
	2N2	F	26	16	Good	
	2N3	F	29	18	Good	
	2N4	F	25	13	Good	
	2N5	M	23	13	Good	
	2N6	F	22	13	Good	
	2N7	F	22	14	Good	
	2N8	F	25	14	Good	
	2N9	F	22	16	Good	
	2N10	F	20	13	Good	
60s	6N1	F	63	13	Good	30
	6N2	F	68	9	migraines	31
	6N3	F	67	16	Good	30
	6N4	F	65	11	Good	30
	6N5	M	67	16	Good	31
	6N6	F	61	16	Good	32
	6N7	M	64	9	hyperthyroid	27
	6N8	F	61	13	Good	32
	6N9	M	60	16	Good	31
	6N10	M	65	18	high chol.	32
70s	7N1	F	74	11	Good	28
	7N2	M	79	10	Good	28
	7N3	M	72	13	Good	31
	7N4	F	72	20	Good	32
	7N5	F	70	11	Good	32
	7N6	M	76	11	Good	31
	7N7	F	76	16	Good	29
	7N8	M	76	16	Good	32
	7N9	F	73	11	Good	28
	7N10	F	76	11	Good	31
80s	8N1	M	80	12	Good	29
	8N2	M	82	9	Good	27
	8N3	F	85	13	Good	31
	8N4	F	81	18	controlled hypertension	31
	8N5	F	83	13	controlled hypertension	30
	8N6	F	80	11	Good	29
	8N7	F	87	11	dilantin	32
	8N8	F	81	11	moderate	32
	8N9	M	82	13	Good	32
	8N10	M	82	13	Good	32

*Mini-Mental Status Examination

scores differed across the age groups. Table 1 provides a summary of background information on the subjects.

Stimulus construction

A total of 120 stimuli were constructed for use in this experiment. First, 30 normal prose sentences, each containing 10 words, were developed. These sentences were designed not to be highly predictable (cf. Cohen & Faulkner, 1983). The word to be monitored for in each sentence (the target word) consisted of a monosyllabic noun, which was selected from among the 200 most frequently occurring nouns (Francis & Kucera, 1982). The position of the target word varied within the sentences; of the 30 normal sentences, 10 contained the target in word positions 2-4, 10 contained the target in word positions 5-7, and 10 contained the target in word positions 8-10. These categories were designated as beginning targets, middle targets, and end targets, respectively.

Table 2. Examples of the stimuli used in the word-monitoring task, with the end target word capitalized.

STIMULUS CONDITIONS	
Normal:	Before beginning his work the man checked the WATER supply.
Anomalous:	After asking her house an eye ordered a WATER duty.
Random:	His the checked beginning man work the before WATER supply.

The 30 normal sentences served as the basis for the remaining experimental conditions in the study. Thus, 30 syntactically appropriate but semantically anomalous sentences were constructed from the normal sentences by changing each word (except for the target) to another word of the same form class and frequency, according to Kucera and Francis (1982). In addition, thirty syntactically and semantically inappropriate sentences were constructed by re-ordering the words in the normal prose sentences (except for the target). The position of the target word remained constant across all sentence types. The words preceding the target in the normal condition also preceded the target in the random condition. Examples of the three sentence types are provided in Table 2.

The 90 sentences and a list of the target words spoken in isolation were recorded onto tape by an adult native English speaking male. The materials were subsequently digitized onto computer at a 10,000 Hz sampling rate using a 4500 Hz low-pass filter and 12 bit quantization. The onset of each target word in each sentence was located on a waveform display and demarcated with a cursor, which triggered the onset of a computer-operated timing mechanism. The timer was stopped when the subject depressed a button on a response board; the resulting reaction time was calculated by and stored on computer. Each target word was paired with the corresponding sentence types using a 500ms inter-stimulus interval. That is, subjects were presented with the monitoring target followed by a sentence containing the target. A 4s inter-trial interval separated the word-sentence pairs. All stimuli were randomized for presentation to the subjects.

Table 3. Group mean word-monitoring reaction times (and standard deviations) in each condition.

GROUP	NORMAL	ANOMALOUS	RANDOM
20s	291 (35)	340 (37)	353 (43)
60s	293 (52)	352 (59)	381 (70)
70s	329 (52)	381 (54)	416 (73)
80s	320 (57)	368 (47)	408 (61)

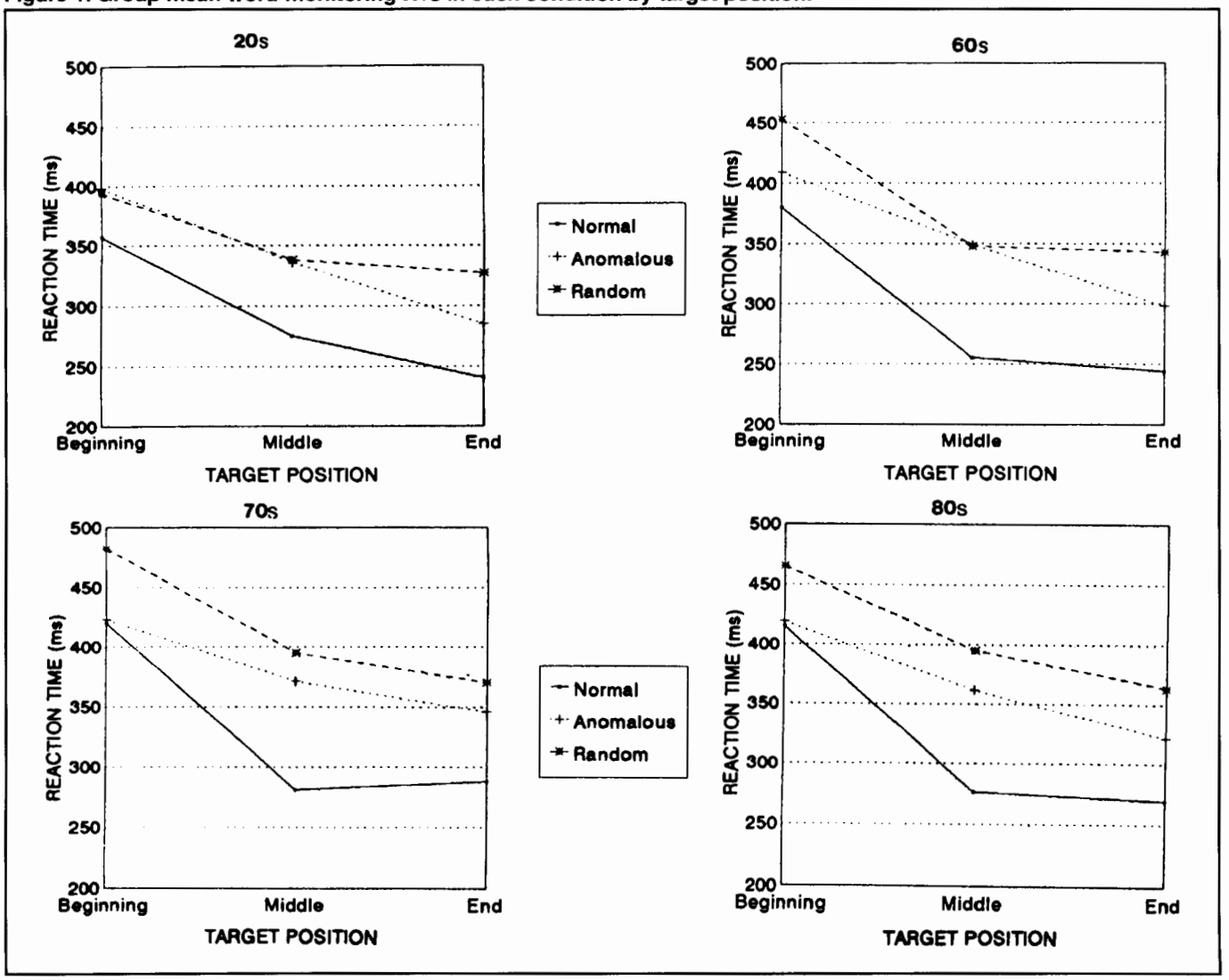
Procedure

Subjects were tested individually in a quiet room. The stimuli were presented through headphones at a comfortable listening level, adjusted for each individual according to the subject's preference. The subjects were told that they would hear a target word followed by a sentence. They were instructed to listen for the target word in the sentence and to depress a response button as soon as they heard that word in the sentence. They were informed that all of the target words would be real words, but that some of the sentences might sound strange.

Results

Mean word monitoring latencies for each subject in each condition were calculated; group mean reaction times (RTs) are displayed in Table 3. As may be seen from the table, all subject groups were sensitive to the manipulations of syntax and semantics, with mean RTs to targets in random word order and anomalous strings slower than RTs to targets in normal sentences. In addition, for all groups, mean latencies to targets in random strings were longer than in anomalous strings. Word-monitoring latencies were further analyzed by sentence position (i.e., beginning, middle, and end targets), with results displayed graphically in Figure 1. As the figure

Figure 1. Group mean word-monitoring RTs in each condition by target position.



shows, mean RTs to later occurring (middle and end) targets were faster than RTs to beginning targets for all groups in all conditions. In general, larger decreases in RT across position were found for the normal sentences as compared to the anomalous and random stimuli. A Group (20s, 60s, 70s, 80s) x Condition (normal, anomalous, random) x Target Position (beginning, middle, end) ANOVA was conducted, which revealed significant main effects for condition ($F(2,72)=124.759$, $p<.001$) and target position ($F(2,72)=146.757$, $p<.001$). In addition, a condition x target position interaction emerged ($F(4,144)=7.915$, $p<.001$). No significant effects of subject group were found. Post hoc Newman Keuls tests ($p<.05$) exploring the condition x target position interaction revealed significant differences between RTs in the normal condition as compared to both anomalous and random conditions at all three target positions. RTs in the anomalous condition were significantly faster than RTs in the random condition for both beginning and end targets, but not for middle targets. Further, within each condition, RTs to beginning targets were significantly slower than RTs to middle and end targets. Somewhat unexpectedly, RTs to middle and end targets differed only in the anomalous condition.

Discussion

Results of the word-monitoring task revealed that subjects in all age groups displayed sensitivity to manipulations of sentential context as evidenced by increased latencies to target words in semantically anomalous and random word order conditions as compared to the normal sentence condition. Of particular interest to the present investigation is the observation that no group differences emerged. On average, RTs for the older subjects were slower than for the younger subjects as expected; however, these differences were not statistically significant. Further, an examination of individual subjects' performance revealed that, all subjects, regardless of age, displayed the same pattern of decreased word-monitoring latencies for targets occurring in stimuli with the greatest contextual support. Moreover, the magnitudes of the differences across conditions were comparable for individual subjects in each group. Consistent with the results of Holtzman et al. (1986) and Madden (1986), the older subjects did not demonstrate an increased reliance on sentential context as compared to the younger subjects (cf. Cohen, 1988; Wingfield et al., 1985). The older subjects in the present investigation were able to make use of both syntactic and semantic contextual information during on-line auditory word monitoring to facilitate word recognition; further, they did so in a manner comparable to that of the younger adults. While our interpretation must be made with caution, these findings suggest that on-line auditory language processing may not be compromised in aging, and that typically older adults may not be more dependent on syntactic and semantic context than are younger adults.

A number of additional findings merit consideration. In particular, the results revealed that word-monitoring latencies decreased across target position in all stimulus conditions for all subject groups. The decrease in RT for later occurring targets in normal and semantically anomalous strings may be interpreted as indicating that the build-up of syntactic or syntactic and semantic structure facilitates word recognition (Marslen-Wilson & Tyler, 1980). The decreased latencies across target positions in the random word order strings, however, was not expected. Because neither syntactic nor semantic cues are available in these stimuli, the observed decrease in RTs in the random condition cannot be a result of the facilitation of structure for later occurring targets; rather, it may be due to the inhibition of RTs to beginning targets due to the proximity of the target to the onset of the stimulus sentence. That is, perhaps subjects were not expecting to hear the target word so soon and RTs were thus increased. On this interpretation, inhibition to beginning targets would be expected across all conditions, as was in fact found. Therefore, if the build-up of syntactic and semantic structure is facilitative of word-monitoring latencies, one would expect to find decreases in latency from middle to end targets in the normal and anomalous conditions but not in the random condition. Such a significant decrease was observed for the anomalous condition but not for the normal strings. The lack of a significant difference between RTs to middle and end targets in the normal condition may be due to a floor effect. That is, latencies in the anomalous condition were decreased from an average of 412ms for the beginning targets to 354ms for the middle targets, whereas latencies in the normal condition were decreased from 393ms to 271ms for beginning and middle targets; the RTs to middle targets in the normal condition were far shorter than those in the anomalous condition and, perhaps, could not be further facilitated by additional structural cues for the end targets. In contrast, RTs to the end targets in the anomalous condition were speeded by the added syntactic information. Further support for this interpretation comes from the finding that RTs for middle targets did not differ in the anomalous and random conditions. The syntactic context present in the anomalous stimuli did not decrease RTs until the end position targets, where RTs were significantly faster in the anomalous as compared to the random conditions.

In sum, the results of the current study are inconsistent with an age-related increase in reliance on sentential contextual cues in on-line language processing. While the present data do not rule out the possibility that older adults may make greater use of pragmatic or other contextual factors, the findings indicate that both younger and older adults are comparably affected by syntactic and semantic context in auditory word-monitoring. Decrements in speed of processing and/or

working memory limitations in older individuals found in previous studies (Cohen, 1988; Klatzky, 1988; Zacks & Hasher, 1988) may not affect normal, on-line linguistic processing.

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