Bulletin of the Psychonomic Society
1992, 30 (4), 301-304

The effect of divided attention on speech production

JERWEN JOU
Georgia Southern University, Statesboro, Georgia

and

RICHARD JACKSON HARRIS
Kansas State University, Manhattan, Kansas

This study examined the effect of divided attention on language production. Subjects recalled information learned and performed mental arithmetic tasks simultaneously. Compared with a no-arithmetic control condition, speech produced in the divided-attention condition showed less information recalled, more frequent prolonged pauses, and extensive deterioration in clausal and sentential structures. Attention deficit seems to disrupt message construction, the smooth flow of speech output, and sentence construction processes in speech.

There are two aspects to language performance, an automatic low-level routinized process and a creative voluntary process. The automatic processes are associated with the phonology of the language, the low-level syntactic organization, and articulatory function, whereas the creative voluntary processes are associated with lexical selection and the construction of conceptual relations (Garrett, 1982; Levelt, 1989). The automatized subroutines of language performance can be executed with little demand on conscious attention. Conversely, the creative voluntary component can be executed only with the consumption of conscious attention (Bock, 1982; Butterworth, 1980; Flores d'Arcais, 1982, 1987a, 1987b; Levelt, 1989). There is evidence that the processing of inflections or other types of basic syntactic rules in a lexical decision task or word-naming task is automatic (Katz, Boyce, Goldstein, & Lukatela, 1987; Lukatela, Kostic, Feldman, & Turvey, 1983; West & Stanovich, 1986; Wright & Garrett, 1984). On the other hand, there have as yet been few studies demonstrating that performance on the higher level language structures in speech production requires much conscious attention.

The present study was undertaken to determine what aspects of speech production would be impaired by attention and memory limitations. The attentional constraint was created by asking subjects to perform two concurrent tasks. In the divided-attention condition, while the subjects were orally recalling what they had learned from a prior task, they were adding up a series of random numbers delivered through earphones. In the full-attention condition, the subjects simply recalled what they had learned. We predicted that the simultaneous mental-addition task would reduce the quantity of information recalled, impede the smooth flow of speech, and degrade the quality of the higher order structure of the sentences (e.g., degrading the completion of a clause or sentence).

METHOD

Subjects

Fifty-two native-English-speaking subjects participated in the experiment for psychology course credit at Kansas State University. Twenty-six of them were assigned randomly to the full-attention condition; the other 26 were assigned to the divided-attention condition.

Materials

Two articles were presented auditorily by a tape recorder. One article (726 words) was a narrative biography of Elizabeth Blackwell, a 19th century woman striving for a medical education and career. The second article (847 words) was an expository discussion of agriculture in developed and developing countries.

In the divided-attention condition, a sequence of 15 random single-digit numbers was used. The first 10 numbers were from 1 to 9 with the number 4 repeated once, presented in one random sequence. The last 5 numbers were from 2 to 5 with the number 3 repeated once, also presented in one random order following the first 10 numbers. A second random order was derived for the same 15 numbers with the same constraints. Both random orders were used for each article, with the order of presentation counterbalanced. The accurate sum for the series of numbers was 66.

Procedure

The articles were read at normal conversational speed by a native-English-speaking American male. First, half of the subjects listened to one of the articles, and the other half listened to the other article (order counterbalanced). When the presentation of the first article was complete, the subjects had 2 min in which to recall orally what they had heard on the tape. Their recall was tape-recorded. Immediately after the recall of the first article, the same process was repeated for the other article. In the full-attention condition, the subjects were told to do their best to recall, in 2 min, as much as possible of what they could remember about the contents of the article.

In the divided-attention condition, the subjects performed the recall and mental-addition tasks simultaneously. The instructions indicated that

An earlier version of this paper was presented at the American Psychological Society Meeting at Washington, DC, in June 1991. We thank James Shanteau, Charles Thompson, and Loren Alexander for their helpful comments. Correspondence concerning this paper may be addressed to Jerwen Jou, Department of Psychology, Georgia Southern University, Landrum Box 8041, Statesboro, GA 30460-8041.

the purpose of this experiment was to investigate people's ability to perform two tasks at once. In the 2-min recall period, the 15 single-digit numbers were presented through earphones. The subjects were asked to recall as much as they could from the article while adding the numbers cumulatively as each number was being read. They were further told to do their best on both tasks and to divide their attention as evenly as possible between the two tasks.

A pilot study had shown that subjects recalled far more in the early part of the 2 min than they did in the later part. Because of this tendency toward decreasing productivity over the 2 min, the presentation of the random numbers was paced at a decreasing rate from 2 sec per digit at the beginning to 15 sec per digit at the end. The interval was increased by about 1 sec for each successive digit. The initially faster rate was used to produce a noticeable disrupting effect on the robust production that occurred early in the recall period. As the total sum accumulated over time, the memory and attentional load might have been building. Progressively slowing the presentation rate would even out the memory and attention load over the whole course of the 2-min recall better than would a uniform rate of presentation.

At the end of recall in the divided-attention condition, the subjects reported the sum of the numbers. The whole experiment took about 40 min.

Scoring

Before scoring the protocols, each of the two articles was analyzed into idea units, roughly equivalent to propositions. The first article yielded 42 idea units; the second article yielded 33 units. The recall protocols were examined and scored in terms of two general categories of dependent measures. The first category was the number of idea units; the second (speech defect) was any departures from the supposedly ideal speech or delivery (Clark & Clark, 1977; Garrett, 1975). The latter category was composed of number of within-clause pauses (5 sec or longer), number of between-clause pauses (5 sec or longer), number of self-corrections (both factual and syntactic), number of retracings (i.e., the repetitions of syllables, words, phrases, or clauses), number of sentence fragments, and number of miscellaneous wrong structures.

RESULTS

The data were analyzed by a set of analyses of variance, with subjects nested within attention but crossed with article and with article crossed with attention. The results showed that subjects in the divided-attention condition produced much less information and much poorer quality of speech than did those in the full-attention condition.

The divided-attention group recalled fewer overall idea units (23.8%) (including true and false) than did the full-attention (33.3%) group [$F(1,50) = 22.17$, $MS_e = .011$, $p < .001$]. The effect of article was also significant, with 33.3% of the ideas recalled for Article 1 and 23.8% recalled for Article 2 [$F(1,50) = 45.74$, $MS_e = .005$, $p < .001$], indicating a different a priori difficulty level for the articles.

Furthermore, the total number of idea units recalled was broken down into true and false units. The proportion of true idea units recalled in the full-attention condition ($M = 32\%$) was significantly greater than that in the divided-attention condition ($M = 20\%$) [$F(1,50) = 43.50$, $MS_e = .009$, $p < .001$]. The proportions of false ideas generated (M for full attention = 1.4%; M for divided attention = 1.8%) were too small to warrant an analysis.

The same analyses were conducted for speech defects, that is, first an overall analysis and then an analysis for each component of the defect. An analysis of overall defects showed that the divided-attention condition produced a significantly higher number of overall defects [$F(1,50) = 62.81$, $MS_e = 17.18$, $p < .001$], with the divided-attention mean more than doubling the mean in the full-attention condition. With overall defects as the dependent measure, no other effects were significant. For mean numbers of the component defects, see Table 1. The attention manipulation produced a significant ($p < .01$) effect on all of the component defects except corrections. A possible explanation for this null result will be suggested in the discussion section.

A separate analysis using number of pauses (disregarding the within–between-clause distinction) as the dependent measure, and attention condition and type of pauses (within- vs. between-clause) as independent variables was performed to test for the attention × type of pauses interaction. The results showed that the attention variable produced a significant main effect on pause [$F(1,50) = 102.10$, $MS_e = 2.16$, $p < .001$], with the divided-attention condition producing more pauses overall (M of full attention = .47; M of divided attention = 2.53). The interaction of attention with type of pauses was also significant [$F(1,50) = 6.68$, $MS_e = 2.59$, $p < .05$]. This significant interaction indicates that the attention manipulation generated differential effects for the two types of pauses, with within-clause pauses being increased more than between-clause pauses.

The overall mean of the totals given by the subjects on the mental addition task across the two articles was 50.96 (the accurate sum was 66). In general, the reported sum was below the correct sum. A significant negative correlation between the proportions of idea units recalled and the magnitudes of the generated sums [$r(24) = -.44$, $p = .001$] suggests that subjects failed to add more numbers to the total when more attention was engaged in recalling information, and vice versa. This tradeoff relationship between the performances of the two concurrent tasks is consistent with findings from many dual-task studies in the divided-attention literature (Navon, 1985; Wickens, 1984).

The generated sum from the mental arithmetic task was also significantly correlated inversely with some speech-defect component measures [with the number of corrections, its correlation was $r(24) = -.31$, $p < .01$; with fragments, it was $r(24) = -.36$, $p < .01$]. These negative correlations suggest that making a self-correction or even uttering a fragment of a sentence is still attention consumptive, despite the fact that such speech is deteriorated.

Table 1
Mean Number of Speech Defects as a Function of Full Vs Divided Attention.

Attention	WCP (15%)	BCP (23%)	Cor. (23%)	Retr. (25%)	Frg. (12%)	WS (2%)	Total (100%)
Full	.21	.73	1.38	1.29	.40	.08	4.1
Divided	2.85	2.21	1.34	2.29	1.50	.35	10.54

Note—WCP = within-clause pause, BCP = between-clause pause, Cor. = corrections, Retr. = retracings, Frg. = fragments, and WS = wrong structures. The numbers in parentheses are the percentages that specific types of speech defect contribute to the total defects.

DISCUSSION

The data showed that the divided-attention condition substantially reduced the quantity of meaningful production and degraded the quality of the linguistic productive performance at the clausal, sentential, and discourse levels. Retrieving the semantic units from memory while speaking required attentional resources. The mental arithmetic task substantially suppressed the message construction process at the conceptual level. The latter finding agrees with the notion that the clausal or higher level structure belongs to the creative voluntary aspects of language performance, which require conscious attention to operate (Garrett, 1982; Levelt, 1989).

Overall, fewer pauses were made in the full-attention condition than in the divided-attention condition. However, under the full-attention condition, more between-clause than within-clause pauses were made, consistent with other findings (Garrett, 1982; Grosjean, 1980), whereas under the divided-attention condition, the reverse was true. The results are consistent with previous findings, which have shown that, relative to between-clause pauses, within-clause pauses are not a frequent phenomenon in normal speech and are restricted to junctures of clearly marked constituents (Butterworth, 1980; Clark & Clark, 1977; Grosjean, 1980). Within-clause pauses were found to be an interval usually not used by the speaker for switching attention to a different channel of information (e.g., to a distractor; Goldman-Eisler, 1980). Thus, under most circumstances in normal speech, the integrity of a clause is kept. The within-clause pauses that were counted in the present data were the ones that were at least 5 sec long. Such a pause is much longer than the maximum length of a between-sentence pause of 2.5 sec normally made in spontaneous speech (Butterworth, 1980). Thus, a silent pause of at least as long as was observed in our data is very rare and unnatural in normal speech. Yet, it increased disproportionately in attentionally strained situations. Such a high frequency of within-clause pauses suggests that completing a clause normally requires some uninterrupted supplying of attentional resources. The concurrent task disrupted a linguistic process that would otherwise have been executed as an integrated unit. The smaller increase in between-clause pauses due to divided attention suggests that a speaker normally stops between clauses longer and more frequently, presumably to plan the next clause (Butterworth, 1980; Ford & Holmes, 1978).

Retracing provides several insights into the process of speech production. Retracing of the elements already uttered prior to a pause seems to be helpful or even necessary to many subjects in order to progress with the sentence. It seems to be a means of providing time for planning the yet-to-be-said words (Deese, 1984). It also serves as a means of keeping track of what has already been said without costing much attention, since maintenance rehearsal costs little or no attention (Naveh-Benjamin & Jonides, 1984). Thus, increased redundancy in speech is a sign of strained attentional resources. Also, it is as though the elements being repeated are some inseparable parts of a processing unit of the sentence and cannot be interrupted within the unit by more than 5 sec and then be continued. When interrupted, the whole unit must be re-uttered from the very beginning.

The more than tripled number of fragments in the divided-attention over that in the full-attention condition (.40 vs. 1.50) indicates that constructing a complete sentence requires sustained attention and perhaps memory as well. There seem to be two sources from which the fragments were derived. First, under an attentionally strained condition, a sentence often could not be continued, probably because the subjects failed to retrieve the searched-for lexical items. Subjects often paused in an "uh . . ." or "uhm . . ." for a long time, as if they could not find the words they wanted, finally giving up the unfinished sentence and starting a new sentence. If speech is produced by undergoing three stages of derivation, a conceptual stage (or a semantic stage), a lexical access stage (finding the right word to express the meaning), and a phonological stage (pronouncing the word) (Garrett, 1975; Levelt, 1983, Schriefers, 1990), such a difficulty would seem to reside most likely in the lexical access stage (Butterworth, 1980). The subjects often had completed almost the whole sentence except for the last word or two. The meaning of these words seemed to have been planned, but the lexical item could not be successfully accessed. Lexical access in some cases might be attention consumptive.

A second source from which the fragments seem to have been derived is that the subjects were interrupted during normal sentence production by a sudden high information processing demand from the second task of hearing an additional number and updating the sum. When the subjects returned to the recall task, they had forgotten the unfinished sentence and thus had to start a new sentence. In this case, the stop was sudden and the pause was a period of complete silence. This is another phenomenon which occurred rarely under the full-attention condition and yet increased remarkably in the divided-attention condition. It is as though the memory of what had already been said was masked by a second memory task, analogous to a visual mask in a perceptual task. Fragments can be easily distinguished from false starts. In the case of false starts, a prompt and forceful correction was usually made; this did not occur in the case of fragments.

The only defect component unaffected by the division of attention was correction. A possible explanation is that correction itself may cost a lot of attention since it presupposes self-monitoring, a process requiring conscious attention (Levelt, 1983, 1989).

Other signs of deterioration in production were informally observed in the divided-attention condition. These included poorer organization of information, less distinct pronunciation, and a softer voice. Also, the subjects under divided attention more often used indefinite pronouns (*things*, *stuff*) to express a meaning.

Neither in the full-attention nor in the divided-attention condition was any violation of basic grammatical rules, such as subject–verb agreement, found. This fact suggests that the application of such rules may be automatic even though the design of the present study was not capable of proving this point unequivocally. See Jou and Harris (1991) for an exploration of the role of such grammatical violations in reading.

REFERENCES

Bock, J. K. (1982). Towards a cognitive psychology of syntax: Information processing contributions to sentence formulation. *Psychological Review*, **89**, 1-47.

Butterworth, B. (1980). Evidence from pauses in speech. in B. Butterworth (Ed.), *Language production: Vol. 1. Speech and talk* (pp. 154-176). New York: Academic Press.

Clark, H. H., & Clark, E. V. (1977). *Psychology and language*. New York: Harcourt Brace Jovanovich.

Deese, J. (1984). *Thought into speech*. Englewood Cliffs, NJ: Prentice-Hall.

Flores d'Arcais, G. B. (1982). Automatic syntactic computation and use of semantic information during sentence comprehension. *Psychological Research*, **44**, 231-242.

Flores d'Arcais, G. B. (1987a). Automatic processes in language comprehension. In G. Denes, C. Semenza, P. Bisiacchi, & E. Andreewsky (Eds.), *Perspectives in cognitive neuropsychology*. Hillsdale, NJ: Erlbaum.

Flores d'Arcais, G. B. (1987b). Syntactic processing during reading for comprehension. In M. Coltheart (Ed.), *Attention and performance XII: The psychology of reading* (pp. 619-633). Hillsdale, NJ: Erlbaum.

Ford, M., & Holmes, V. M. (1978). Planning units and syntax in sentence production. *Cognition*, **6**, 35-53.

Garrett, M. F. (1975). The analysis of sentence production. in G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 9, pp. 133-177). New York: Academic Press.

Garrett, M. F. (1982). Production of speech: Observations from normal and pathological language use. In A. W. Ellis (Ed.), *Normality and pathology in cognitive functions* (pp. 19-76). London: Academic Press.

Goldman-Eisler, F. (1980). Psychological mechanisms of speech production as studied through the analysis of simultaneous translation. In B. Butterworth (Ed.), *Language production: Vol. 1. Speech and talk* (pp. 142-153). New York: Academic Press.

Grosjean, F. (1980). Linguistic structures and performance structures: Studies in pause distribution. In H. W. Dechert & M. Raupach (Eds.), *Temporal variables in speech: Studies in honor of Frieda Goldman-Eisler* (pp. 91-106). New York: Mouton.

Jou, J., & Harris, R. J. (1991). Processing inflections: Dynamic processes in sentence comprehension. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **17**, 1082-1094.

Katz, L., Boyce, S., Goldstein, L., & Lukatela, G. (1987). Grammatical information effects in auditory word recognition. *Cognition*, **25**, 235-263.

Levelt, W. J. M. (1983). Monitoring and self-repair in speech. *Cognition*, **14**, 41-104.

Levelt, W. J. M. (1989). *Speaking: From intention to articulation*. Cambridge, MA: MIT Press.

Lukatela, G., Kostic, A., Feldman, L. B., & Turvey, M. T. (1983). Grammatical priming of inflected nouns. *Memory & Cognition*, **11**, 59-63.

Naveh-Benjamin, M., & Jonides, J. (1984). Maintenance rehearsal: A two-component analysis. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **10**, 369-385.

Navon, D. (1985). Attention division or attention sharing? In M. I. Posner & O. S. M. Marin (Eds.), *Attention and performance, XI* (pp. 133-146). Hillsdale, NJ: Erlbaum.

Schriefers, H. (1990). Lexical and conceptual factors in the naming of relations. *Cognitive Psychology*, **22**, 111-142.

West, R. F., & Stanovich, K. E. (1986). Robust effects of syntactic structure on visual word processing. *Memory & Cognition*, **14**, 104-112.

Wickens, C. D. (1984). Processing resources in attention. In R. Parasuraman, R. Davies, & J. Beatty (Eds.), *Varieties of attention* (pp. 63-102). New York: Academic Press.

Wright, B., & Garrett, M. (1984). Lexical decision in sentences: Effects of syntactic structure. *Memory & Cognition*, **12**, 31-45.

(Manuscript received February 21, 1992.)