Effects of Divided Attention on the Production of Filled Pauses and Repetitions

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The purpose of the present study was to examine effects of divided attention on the production of filled pauses and repetitions. Attention was divided by means of a dual-task paradigm. Eighteen nonstuttering adult subjects performed a picture story-telling task, with and without simultaneously performing a tactile-form recognition task. Results indicate that the number of filled pauses and repetitions increased in a situation of divided attention. This suggests that the production of filled pauses and repetitions, which are considered to be reactions to problems in speech planning, is governed by processes that operate relatively independently of the available attentional resources. It was speculated that these disfluencies could be automatic reactions to the increased planning difficulties induced by the concurrent task.

KEY WORDS: disfluencies, divided attention, dual task, filled pauses, stuttering

Spontaneous speech is rarely fluent, but is often filled with disfluencies such as filled pauses (e.g., *uh*, *um*) and repetitions of sounds, words, or phrases. Filled pauses and repetitions are typically thought to reflect problems in the speech-planning process. Filled pauses have been associated with lexical search phenomena, indicating that the speech-planning process is searching for the next word (Christenfeld, 1994; Wingate, 1984). In addition, both filled pauses and repetitions may signal problems in constituent construction. Boomer (1965) demonstrated that filled pauses were most frequent at the beginning of encoding units. Similarly, Clark and Wasow (1998) report that word repetitions in two corpora of spontaneous speech increase with Noun Phrase complexity.

The foregoing planning difficulties have been related more specifically to temporal problems in speech planning. Clark and Clark (1977) argued that filled pauses and repetitions indicate that speakers are interrupting execution for additional planning activities. Clark and Wasow (1998) further reason that the repetition of a word reflects a speaker's attempt to redo a constituent in its ideal delivery. In addition, Blackmer and Mitton (1991) suggested that repetitions derive from an "autonomous restart capacity" in the articulator, which restarts the articulation of the phonetic plan if it runs out of material for a new phonetic plan to articulate. Relatedly, Au-Yeung, Howell, and Pilgrim (1998) and Howell, Au-Yeung, and Sakin (1999) describe how temporal problems in the execution of the speech plan can explain stuttering phenomena.

A different approach to filled pauses and repetitions is provided by Levelt (1983, 1989) and in Postma and Kolk's (1993) Covert Repair Hypothesis (CRH). They suggest that filled pauses and repetitions are the result of covertly repaired segmental speech errors. Errors are detected by a "perceptual loop" monitor (Levelt, 1983, 1989) that can check inner speech before articulation and overt speech. Some of these errors are detected prearticulation at such an early point in time that the error itself does not become overt. The result of such covert repair activity is a disfluency in overt speech: either a filled pause or a repetition. The CRH applies to normal and stuttered speech (Postma & Kolk, 1993). In the CRH and in Levelt's perceptual loop theory, disfluencies are considered to be reactions to segmental errors, whereas Clark and Clark (1977), Blackmer and Mitton (1991), and Clark and Wasow (1998) argue that they are reactions to temporal distortions. Thus, both views share the idea that disfluencies are reactions to problems that originated during speech planning, but that the type of problem differs.

Of particular interest is the question whether the reactive responses discussed above result from attentional, controlled processes or from automatic processes. The purpose of this study was to address this question by examining how limitations in central attentional resources affect the production of filled pauses and repetitions. If the production of filled pauses and repetitions, which are considered to be reactions to problems in speech planning, is governed by attentional processes, the number of filled pauses and repetitions should decrease in a situation in which there is less room for attentional control. If, in contrast, filled pauses and repetitions are automatic reactions to speech-planning problems, their occurrence would be relatively independent of central attention.

The distinction between attentional and automatic processes is one of the central issues of debate in disfluency theories. Levelt's perceptual loop monitor (1989) is an attentional, centrally regulated mechanism, which implies that the production of disfluencies is always under attentional control. The temporal approach has favored both attentional and automatic accounts. Maclay and Osgood (1959) and Holmes (1988) argue that filled pauses occur as a reaction to the awareness of one's own silence or hesitancy. Likewise, Clark and Wasow (1998) suggest that disfluencies primarily result from strategies that occur after speakers have made a preliminary commitment to an utterance, in order to restore continuity. If disfluencies reflect such strategic decisions, they seem to be the result of speakers' conscious attention to their own speech. In contrast, it has also been suggested that disfluencies result from automatic processes. Clark and Wasow (1998) argue that besides being strategically driven, repetitions can also result from "pure" (automatic) processes—that is, when speakers resume speaking after a hiatus, they repeat the last word produced because it is the most highly activated one. The "autonomous restart capacity" in the articulator, proposed by Blackmer and Mitton (1991), is assumed to operate automatically. The role of automaticity in disfluency production has been a topic of discussion in both the stuttering and normal disfluency literature (Bloodstein, 1975; Eisenson, 1958).

In what way do limitations in attentional resources affect ongoing cognitive processes? In the working-memory model of Baddeley and Hitch (1974), a central component of working memory is responsible for the allocation of the attentional resources that are available for online cognitive processes. A situation of limited attentional resources arises when the number of required resources exceeds the available resources. Shiffrin and Schneider (1977) argued that centrally regulated processes require a large number of resources and will therefore be affected in situations of limited resources. In contrast, automatic processes will not be hindered by resource limitations, as they need relatively few attentional resources. In order to examine whether processes are dependent on the available attentional resources or if they are running automatically, a situation of limited resources is often experimentally created by means of a "dual task paradigm" (Pashler, 1994). In a dual-task situation, in which two cognitively demanding tasks are performed simultaneously, attentional resources have to be divided between both tasks. If a large number of attentional resources is required for the tasks, performance on the tasks will be reduced (Baddeley & Hitch, 1974; Norman & Shallice, 1983).

Studies examining stuttering have used the dual-task paradigm to examine effects of divided attention on stuttering frequency. Both Arends, Povel, and Kolk (1988) and Thompson (1985) tested the hypothesis that stuttering is the result of speakers' over-attention to their own speech, caused by a controlled speaking mode. Distracting stutterers from attending to their speech would therefore reduce stuttering. This hypothesis is in accordance with the notion discussed above that filled pauses and repetitions in nonstuttered speech are the result of centrally governed, attentional processes. Arends et al. (1988) compared stuttering frequency in a single speech task (spontaneous recall of a fairy tale after having read it) to stuttering frequency in a situation of divided attention (spontaneous recall and visual tracking). The results demonstrated that divided attention leads to a decrease in stuttering frequency, which provides evidence for the notion that stuttered disfluencies are the result of attentional control. However, this was the case only for severe stutterers. In a similar study, Thompson (1985) examined the stuttering frequency of stutterers and nonstuttering controls in single speech tasks, consisting of recitation of rhymes and spontaneous description of pictures, and in a situation of divided attention (recitation of rhymes and the spontaneous description with simultaneous visual tracking). In contrast to Arends et al. (1988), Thompson (1985) obtained no effect of divided attention on disfluency rate, neither for stutterers nor for nonstuttering controls. The difference in results might be explained by the severity of stuttering, as the stutterers of Arends et al. were more severe stutterers than those of Thompson (Arends et al., 1988).

Kamhi and McOsker (1982) also investigated the ability of stutterers and nonstutterers to simultaneously perform speech and nonspeech tasks. Subjects performed an attention-demanding task (reading comprehension) and a non-attention-demanding motor task while reading aloud. Results indicated that stutterers performed more poorly than nonstutterers on reading comprehension, which was taken as evidence that stutterers devote more attention to their speech than nonstutterers. However, neither the presence of the reading comprehension task nor the presence of the motor task affected the number of disfluencies in the speech task.

As opposed to the idea that disfluencies, which are reactions to speech-planning problems, result from central, attentional processes, filled pauses and repetitions could also be automatic reactions to speech-planning problems. In this case, their occurrence would be relatively independent of central attention. A situation of divided attention would therefore not lead to a decrease in filled pauses and repetitions. Possibly, they might even increase, as speech production could suffer from breakdown when too little attentional resources are available for speaking (cf. the overload hypothesis of Arends et al., 1988). Support for this is provided by Jou and Harris (1992), who tested the effect of divided attention on the production of repetitions by means of a dual-task paradigm. In this study, subjects who did not stutter listened to texts that were read aloud, after which they had to recall orally what they had heard. In the divided-attention condition, the subjects had to orally recall a text and simultaneously perform a mental arithmetic task (adding up a series of random numbers). The results demonstrated that the number of repetitions increased in the divided-attention condition.

Thus, research in this area provides conflicting results. In an attempt to shed more light on these discrepant findings, the present study attempted to further examine how a situation of divided attention affects the production of disfluencies in normal speech. Subjects who did not stutter had to perform a picture-story description task, both alone and in combination with a tactile-figure recognition task. In order to create a situation of limited resources by means of a dual-task paradigm, both tasks must be sufficiently cognitively demanding and require a substantial amount of attention. The picture-story telling task is more cognitively demanding and requires more attentional resources than the reproduction tasks of Arends et al. (1988) and Jou and Harris (1992), as it includes the process of conceptualization of the stories, which is highly dependent on the available attentional resources (Levelt, 1989). In addition, in the tactile recognition task, a considerable amount of central attention had to be invested in exploring a tactile stimulus without being able to see it, in constructing a representation, as well as in keeping the representation of the figure active in working memory. A tactile task was used because it could easily be combined with the speaking task. Furthermore, in contrast to Jou and Harris (1992), this study focused on the production of two types of disfluencies that are very common in normal speech—namely, filled pauses and repetitions.

Method

Participants

Eighteen paid undergraduates of Utrecht University participated in the experiment (11 women and 7 men). They ranged in age from 19 to 24 years. The subjects were native speakers of Dutch and did not report any history or treatment of speech, language, or hearing disorders. None of them had prior experience participating in description experiments or dual-task experiments. In addition, none of them had unusual experience in extemporaneous speaking or in fingertip activities such as piano playing.

Materials

The experimental materials consisted of 10 black-and-white picture stories for the story- telling task and 22 sandpaper figures for the tactile-form recognition task. Eight picture stories consisted of six pictures each; the other 2 consisted of eight pictures each.

The picture stories were also used by Van Hest (1996), who preselected them from Heaton (1981), Hill (1969), and Mayer (1981) and piloted their applicability. The pictures for each story were presented one by one. This elicits more disfluent behavior than picture stories that are presented as a whole (Van Hest, 1996).

In addition, the subjects had to explore sandpaper figures (that they were not able to see) with stheir dominant hand. The figures were taken from a neuropsychological tactile-form perception task (Benton, Sivan, Des Hamsher, Varney, & Spreen, 1983) and were attached to white cardboard. In addition, for each figure, four multiple-choice options were printed on white cardboard. Among these options was the sandpaper figure; the other three were distractors. The Appendix shows an example of a figure and its options and an example of a picture story. A wooden box, whose front was closed except for an opening for the hand (from the bottom to 15 cm), was used to prevent the subjects from seeing the figure. At the back, the box was open, which gave the experimenter the opportunity to watch the subjects' hands.

Design and Procedure

The experiment included two single-task conditions—the figures-only and the speech-only conditions—and one divided-attention condition. The figures-only condition was always conducted first, to ensure that the subjects were familiar with the task in the divided-attention condition and to ensure that effects in this condition would be the result of distraction, not confusion. The order of the two other conditions was counterbalanced across subjects. Figures and picture stories were randomly selected for each subject and each condition. The order of presentation of the picture stories and of the figures was randomized.

The subjects were tested individually in a quiet, small room. Their descriptions were audio-recorded by a Monarch microphone on a Sony tape recorder. The experimental conditions were preceded by instructions and by a practice phase, which included practice trials for each condition. Before the start of each new condition, (specific) instructions were given/repeated.

In the figures-only condition, subjects explored sandpaper figures. They were instructed that they could explore each figure for a maximum of 30 s, with the aim of being able to recognize the figure from four multiple-choice options. After the subjects had explored two figures in a row, the four options were shown for each figure (in the same order as in the exploration). The subjects had to choose the one they had explored. Subsequently, the next figure was presented, and so forth. There was one trial in which the subjects explored three figures in a row, in parallel to the eight picture-story trial in the divided-attention condition. In total, 11 sandpaper figures were explored in this condition.

In the speech-only condition, subjects described 4 six-picture stories and 1 eight-picture story. The subjects were instructed to describe the pictures as accurately as possible. They were told that the pictures would add up to a story and that they should therefore try to make a coherent story that would be understandable for a listener. In addition, before the start of each story they were informed how many pictures there were for the story (six or eight pictures). The subjects had to start speaking as soon as they received the first picture.

In the divided-attention condition, subjects described 4 six-picture stories and 1 eight-picture story and simultaneously explored sandpaper figures. They were instructed to speak and actively explore the figure at the same time. The experimenter, who observed each subject's hand, gave feedback on this in the practice phase and, if necessary, in between the stories. This was rarely necessary. For the six-picture stories, the subjects explored two figures in a row (figure change after the third picture); for the eight-picture story, they explored three figures in a row (figure change after the third and the fifth picture). The subjects were told before each picture story when the figure change(s) would take place. The figure changes were accomplished smoothly by the experimenter, in such a way that the subjects could continue their description without interrupting it. After they had finished describing a story, the printed multiple-choice options for the figures were shown (in the same order as in the exploration), and subjects had to choose the figures they had explored from the alternatives.

Data Scoring

The subjects' descriptions were nonphonetically transcribed from the tape-recordings by the first author, who is an experienced transcriber. The first author also identified and coded the filled pauses and repetitions from the tape-recordings. Table 1 shows examples of filled pauses and repetitions that were included. Filled pauses were defined as the sounds *uh, um, er,* and *ah* (cf. Christenfeld, 1996). Only "vocalized pauses" were included. Interjections that were part of overt self-repairs of speech errors (e.g., "the girl > uh the boy") were excluded from the analysis. Repetitions comprised

Table 1. Examples of filled pauses and repetitions.

Type of disfluency	Example
Filled pauses	een meneer staat eh de bloemen te sproeien (a man is uh watering the flowers)
	Ehm het is echt in de nacht (Uhm it is really in the night)
Repetitions	
Sound repetitions	om d > dichterbij te komen (to come c > closer)
Word repetitions	met met bloemen (with with flowers)
Phrase repetitions	en bijt in de in de tuinslang (and bites in the in the hose)

sublexical repetitions (sound or part-word repetitions), lexical repetitions (word repetitions), and supralexical repetitions (phrase or multiple-word repetitions) (cf. Postma and Kolk, 1992). If there was more than one iteration in a sound, word, or phrase repetition (e.g., "the the the customer"), this was counted as only one repetition. The majority of the repetitions included one iteration. Overall, only nine repetitions (six word repetitions and three phrase repetitions) included two iterations, and there was only one (word) repetition that included three iterations. This suggests that in most repetitions no struggle (often associated with stuttered disfluency) was observed. Speech errors (syntactic, lexical, and phonological errors) were also coded.

Reliability

In order to check for reliability of the transcriptions and the coding of disfluencies, a second experienced transcriber independently transcribed 20% of the descriptions (one description in each condition per subject) and identified and coded the disfluencies in these descriptions in the same way as the first author. Interjudge agreement was calculated on the total counts of filled pauses, on the total counts of repetitions, and on the total counts of interjections that were part of revisions. Agreement was 93% for filled pauses, 91% for repetitions, and 88% for interjections that were part of revisions. The number of interjections that were part of revisions was very small (i.e., the transcribers agreed on 14 of the 16 interjections that were part of revisions). A final decision about those filled pauses (7%), repetitions (9%), and interjections associated with revisions (12%) that initially were not coded identically by the two independent transcribers was reached by consensus. This involved re-listening to the relevant speech samples and discussion between the two transcribers.

Results

Picture-Story Description

The average length of a picture description was 154 (SD = 56) words in the speech-only condition and 168 words (SD = 65) in the divided-attention condition. As the number of spoken words varied across subjects and across conditions the number of filled pauses and the number of repetitions were calculated per 100 spoken words per subject for each condition.

Table 2 shows the mean frequencies of filled pauses and repetitions. Paired-samples t tests demonstrated that in the divided-attention condition more filled pauses [$t(17) = 2.85$, $p < .05$] were produced than in the speech-only condition. This effect was present in 14 of the 18 subjects. In addition, more repetitions [$t(17) = 2.39$, $p < .05$] were produced in the divided-attention condition than in the speech-only condition. Again, this effect was present in 14 of the 18 subjects. There was only one subject who did not demonstrate an increase in both filled pauses and repetitions.

As a number of subjects did not produce each different type of repetition (sound/part word, word, and phrase repetitions) in both conditions, parametric analyses of the different types of repetitions were not possible. However, it was possible to test nonparametrically whether the proportion of the different types of repetitions differed in the speech-only condition and in the divided-attention condition. If the proportions were equal in both conditions, this would indicate that the overall increase in repetitions is present for all types of repetitions. Chi square tests were conducted on the total numbers of the different types of repetitions in both conditions. As indicated in Table 3, the total number of sound and word repetitions increased in the divided-attention condition, whereas the number of phrase repetitions slightly decreased. A chi square test confirmed that the proportions of the different types of repetitions were significantly different in the speech-only condition from those in the combined condition [$\chi^2(2) = 7.1$, $p < .05$]. Both the proportion of sound/part-word repetitions [$\chi^2(1) = 7.0$, $p < .01$] and the proportion of word repetitions [$\chi^2(1) = 4.0$, $p < .05$] differed from the proportion of phrase repetitions. In contrast, there was no difference between the proportion of sound/part-word repetitions and the proportion of word repetitions in the two conditions [$\chi^2(1) = 1.9$, n.s.]. Hence, in the divided-attention condition sound/part-word repetitions and word repetitions increased, but phrase repetitions did not.

The mean number of overt speech errors was similar in the speech-only condition (.70) and in the divided-attention condition (.80) [$t(15) = 1.18$, $p < 1$].

Table 2. Mean disfluency frequency (and standard deviations) per 100 words.

Type of disfluency	Speech only			Divided attention		
	M	*SD*	Total	*M*	*SD*	Total
Filled pauses	2.68	1.68	419	3.47	1.19	564
Repetitions	0.65	0.60	107	0.97	0.69	158

Table 3. Total numbers of sound, word, and phrase repetitions.

Type of repetition	Speech only	Divided attention
Sound repetitions	19	44
Word repetitions	62	93
Phrase repetitions	26	21

Tactile-Form Recognition

In the divided-attention condition, the presence of the speech-production task also affected performance on the tactile-form recognition task. The mean percentage of correct answers on the multiple-choice options was higher in the figures-only condition (77.44%) than in the divided-attention condition (60.33%). This difference was significant [$t(17) = 4.359$, $p < .001$]. The comparison is complicated by the fact that all subjects started with the figures-only condition, but it appears that despite having less practice in the figures-only condition, subjects still performed better in this condition than in the divided-attention condition.

Discussion

The purpose of the present study was to examine by means of a dual-task paradigm how limitations in central attentional resources affect the production of filled pauses and repetitions. The results demonstrated that the number of filled pauses and repetitions increased in a situation of divided attention. These findings do not support the hypothesis that these disfluencies are attentionally governed reactions to speech-planning problems; rather they suggest that they are governed by processes that function relatively independently of central attention.

How exactly did the concurrent task affect speech production and lead to a larger number of filled pauses and repetitions? As mentioned before, the story-telling task required conceptualization of the stories, which is a process that demands a large degree of attentional resources (Levelt, 1989). The presence of a concurrent task, which also requires a large degree of attentional resources, could therefore lead to resource limitations. Being a centrally regulated, attentional process, conceptualization would suffer from these resource limitations, which would lead to more planning problems. However, the production of filled pauses and repetitions is not hindered by these limitations, but rather seems to increase automatically with the increased planning difficulty induced by the concurrent task.

It could be speculated at this point that problems in conceptualizing might result in a general slowing down of the speech-planning process (i.e., a slower conceptualizing process and more time required for word-finding). This, in turn, could cause an elevation in the number of temporal problems in speech planning. As this is highly speculative, the possibility that temporal problems in speech planning are a primary source for the occurrence of disfluencies needs further investigation. This possibility has also been applied to speech disfluency in speakers who stutter (Au-Yeung et al., 1998; Kent, 1984; Perkins, Kent, & Curlee, 1991; Van Riper, 1971). Van Riper (1971) proposed that stuttering could result from a temporal disruption of the linking of sounds and syllables that constitutes the motor patterns of a word. Similarly, Kent (1984) suggested that an important difference between stutterers and nonstutterers lies in the capacity to generate temporal programs, or time structures of actions. Thus, disfluencies in normal as well as in stuttered speech might result from temporal problems in speech planning. This is confirmed by studies which demonstrate that the number of disfluencies *decreases* when normal speakers or stutterers synchronize their speech to the rhythm of a metronome, which simplifies the temporal structure of speech (Brayton & Conture, 1978; Christenfeld, 1996; Fransella & Beech, 1965).

The presence of a concurrent task did not affect the production of overt segmental speech errors. This argues against the idea that disfluencies are exclusively reactions to segmental errors, which is suggested by Levelt (1983, 1989) and which is a central claim of the CRH (Postma & Kolk, 1993). However, Postma and Kolk (1993) noted that covert repairs could also be reactions to delays in word-finding or reactions to temporal asynchronies in the availability of segments and syllable frames in which the segments have to be inserted, as suggested by Perkins et al. (1991).

Not only did the tactile-figure recognition task affect speech production, the reverse was also true—that is, the presence of a speech task also reduced the performance on the tactile-figure recognition task. These findings are in line with earlier findings demonstrating that in a divided-attention situation, a speech task reduces the performance on the concurrent task (Clarici, Fabbro, Bava, & Daro, 1994; Hiscock, 1982; Oomen & Postma, in press). This indicates that the tactile recognition task is also dependent on the available attentional resources. It must be noted at this point that Arends et al. (1988) suggest that a concurrent task that is not continuous might not be compelling enough to really affect a simultaneously performed speech task. However, the effects found on both tasks in the situation of divided attention suggest that the two tasks of the present study are to a high degree dependent on shared central attentional resources.

The findings of the present study are in line with those of Jou and Harris (1992), who observed a larger number of repetitions in a situation of divided attention. Both in the present study and in the study of Jou and Harris, the presence of a concurrent task reduced the attentional resources required for speech planning. As a result, the subjects experienced more planning problems and automatically produced more disfluencies. It must be noted that the finding that the production of filled pauses and pauses and repetitions is governed by processes that operate independently of the available attentional resources does not necessarily imply that there cannot be any strategic influences. Filled pauses, sound repetitions, and word repetitions might reflect strategies that can operate without a large amount of central attention. For example, Jou and Harris (1992) explicitly state that repetitions could serve as a means of keeping track of what has already been said without costing too much attention. However, it could be speculated that the absence of an increase in phrase repetitions (which were not frequent overall) might suggest that repeating a phrase is relatively more dependent on the available attentional processing resources than the more automatically produced sound and word repetitions.

In sum, the present study demonstrated that in a situation of divided attention, which reduced the number of attentional resources that speakers can allocate to their own speech, normally fluent speakers produced more filled pauses and repetitions than in a normal speech situation. This suggests that the production of filled pauses and repetitions is governed by processes that operate relatively independently of the available attentional resources. Rather, these disfluencies seem to be automatic reactions to (temporal) problems in speech planning, which increase as a result of the presence of a concurrent task.

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Appendix

Sandpaper figure

Multiple-choice figures

Picture story