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Function Word Repetitions Emerge When Speakers Are Operantly Conditioned to Reduce Frequency of Silent Pauses

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Abstract

Beattie and Bradbury (1979) reported a study in which, in one condition, they punished speakers when they produced silent pauses (by lighting a light they were supposed to keep switched off). They found speakers were able to reduce silent pauses and that this was not achieved at the expense of reduced overall speech rate. They reported an unexpected increase in word repetition rate. A recent theory proposed by Howell, Au-Yeung, and Sackin (1999) predicts that the change in word repetition rate will occur on function, not content words. This hypothesis is tested and confirmed. The results are used to assess the theory and to consider practical applications of this conditioning procedure.

Keywords

pauses; function; content; fluency; stuttering

INTRODUCTION

There has been considerable interest over the years in the role of pauses in spontaneous speech, in particular, whether they allow fluent speech control to be maintained. In an interesting variant on procedures used to investigate this issue, Beattie and Bradbury (1979) reported a verbal, operant-conditioning study. Silent pauses were detected electronically and a light was switched on when they occurred. Speakers were told to stop the light from going on (they were not given any specific instructions how to do this) while at the same time maintaining the same speech rate. In order to get the light to stay off, speakers have to fill the silent gap in some way. Results indicated that they could control their speech so the light was lit infrequently. Their results showed that one way they achieved this was by increasing number of word repetitions. These findings are consistent with the view that speakers use silent pausing for cognitive planning (Butterworth, 1975; Goldman-Eisler, 1972) and when dissuaded from doing this, they achieve the same goal by employing other forms of hesitation.

Although this result stresses the equivalent role of different forms of hesitation phenomena, the attention given to pauses has far outweighed that to other forms such as word repetition. An exception to this is in a separate area of research (Clark & Clark, 1977) where repetition phenomena have attracted significant attention. Clark and Clark (1977) noted that when fluency breaks down in spontaneous speech, speakers frequently repeat pronouns and

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conjunctions. Pronouns and conjunctions are types of function words, which is a closed class of words (no new ones are added) that have a grammatical, or functional, role but do not carry a full lexical meaning (Hartmann & Stork, 1972; Quirk *et al.,* 1985). As well as pronouns and conjunctions, the function word category also includes articles, prepositions, and auxiliary verbs. Au-Yeung, Howell, and Pilgrim (1998) have shown that word repetition happens not just on pronouns and conjunctions, but on function words, in general.

Function words are to be contrasted with content words which is the class that contains all remaining words. This class is open (a linguistic set that can be extended throughout life) and the types of word included are nouns, main verbs, adverbs, and adjectives. There have been no reports in the literature of content word repetition. This type of word is, however, associated with semantic-type speech errors (Levelt, 1992) and it is also the type of word used to test for tip-of-the-tongue (TOT) states (Caramazza & Miozzo, 1997; Miozzo & Caramazza, 1997). Furthermore, in one acute form of fluency failure (stuttering in adulthood), part-word fluency failures occur on content words (Brown, 1945; Howell, Au-Yeung, & Sackin, 1999). Thus, for example, adults who stutter, prolong or repeat the first part of content words. The findings from TOT studies also show that the part of these words is available when a person experiences this state on a word (Caramazza & Miozzo, 1997; Miozzo & Caramazza, 1997). Note that the difference in type of speech errors across lexical forms may be related to differences in complexity, as content words are complex in comparison with function words in English (Howell, Au-Yeung, & Sackin, 2000).

One explanation for the different types of error observed on content (semantic) and function (repetition) words is that each type of word is linked with different ways of maintaining fluency: Function word repetition might stall speech so that the plan for a subsequent content word can be completed (Clark & Clark, 1977), whereas fluency failures on content words may occur when the speaker commences saying the word when only the first part of the plan is ready (Howell *et al.,* 1999). This hypothesis suggests that function words have a similar role to pausing (i.e., they allow more planning time for the up-coming stretch, particularly when that stretch contains difficult, usually content, words occurring in complex phonological or syntactic structures).

There are several pieces of evidence that are consistent with the view that repetition of function words allows more time for planning subsequent complex words, as also hypothesized to occur during pauses. First, Strenstrom and Svartvik (1994) reported a study on fluency breakdown on pronouns in fluent speakers. They analyzed pronouns that occurred before and after verbs (or prepositions for objective pronouns) extracted from the London-Lund corpus of Spoken English. Pronouns were chosen as their position relative to a verb is easily established in English since they have different lexical forms depending on their position (e.g., the two forms of the first person pronoun in *"Tommy has known me since I was eight."*). Strenstrom and Svartvik found that 3.39% of subjective personal pronouns in English (e.g., I, he, we, they, she) were repeated compared with 0.14% of objective personal pronouns (e.g., me, him, us, them, her). As subjective pronouns always precede and objective pronouns always follow a verb, this can be interpreted as repetition of function words predominantly occurring prior to content words. This is also consistent with the view that fluency failure on function words delays production of a subsequent content word.

A second piece of evidence was presented by Au-Yeung *et al.* (1998) who looked at the issue of which function words are repeated in more depth than Strenstrom and Svartvik. They developed a method of dividing all speech so the position of a function word relative to adjacent content words can be unambiguously determined. Such a procedure is needed because function word affiliation with content words is ambiguous when they appear

between two content words (e.g., to establish whether the function word since in “me since I,” in the previous example, follows “known” or precedes “was”). The procedure was adapted from the work of Selkirk (1984) (see Howell *et al.,* 1999, for full details). A phonological word consists of a content word and any number of function words that serve as prefixes or suffixes to the content word. All function words must be associated with a content word. Thus, segmentation of speech into phonological words achieves two important things: (a) All of them include a complex (content) word, and (b) the position of function words relative to the content word it is associated with can be ascertained. After the transcribed speech data were segmented into phonological words, the function words in each phonological word were classified either as pre- or postcontent word. Only repetition of function words preceding the content word can gain time for planning the content word. The mean percentages of fluency failures on function words preceding and following the content word were calculated for different age and fluency groups (fluent speakers and speakers who stutter were investigated). For all age and fluency groups, function word repetition happened almost exclusively on function words that preceded content words. This is consistent with the view that function word repetition has a delaying role for fluent speakers and for speakers who stutter.

The Beattie and Bradbury (1979) study is important from this perspective because it suggests pauses (in their case, silent ones) and word repetition operate reciprocally. If one way of pausing is prohibited, another will emerge so communication can be maintained. Other evidence that is consistent with this is the Blackmer and Mitton (1991) work that shows callers to late-night radio programs use a lot of word repetition. Although they do not explicitly state whether it is the function words that are repeated, all the examples of repetition they give are on function words. Therefore, this is consistent with the view that speakers do not want to pause silently and lose the floor (a particularly acute problem when speaking live to a radio compere) so they repeat function words already said until they are ready to get their message out. Gee and Grosjean (1983) showed pausing frequently precedes a function-content word unit, but occurs hardly at all at the boundary between the function and content words. The units they used in their analysis closely approximate the phonological words used by Howell *et al.* (1999). The Gee and Grosjean study can be interpreted as showing, then, that speakers pause before they embark on one of these units and doing so avoids the risk of repetition of function word (the converse of what Beattie and Bradbury showed). Related to the evidence from Gee and Grosjean’s (1983) work, Pinker (1995) has given examples showing that pauses do not always occur at a major syntactic boundary. In the examples used to illustrate this, the pauses do, however, all occur at phonological word boundaries. Again, this is consistent with speakers pausing prior to a unit involving a difficult content word so as to avoid the situation calling for function word repetition. The Pinker examples also specifically rule out delaying a role in syntactic units.

Knowing whether function words are repeated when silent pauses are conditioned out would allow the role of pausing and repetition to be linked to theories that are being developed to establish what linguistic units are used for organizing speech output, the reason why fluency fails in these units on occasions, the ways available to speakers to recover from these failures, and the dangers (in terms of persistent fluency failure) inherent to different forms of dealing with fluency failure. The following study is a partial replication of Beattie and Bradbury’s (1979) experiment that extends their analysis to see whether repetition occurs on the simpler, function words. The theoretical ramifications are returned to in the Discussion as well as consideration of a practical application the results might be relevant to.

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METHOD

Subjects

Four undergraduate or postgraduate students from University College London acted as subjects. All were male and native English speakers, free of any obvious speech defect. They were well-practiced in performing speech experiments.

Apparatus

A voice-operated switch was used to detect silences. The voice-operated switch activated a red light whenever a pause of 600 msec or longer was detected. The light remained on until the speaker recommenced and more sound was detected. The speech and output from the voice-operated switch were recorded on separate channels on a DAT recorder.

Procedure

Subjects were given practice before the experiment started. The same experimenter tested all subjects. Subjects were asked to select a topic of conversation from a number suggested to them (hobbies, report of a film, etc.). They commenced the story immediately after they had made their choice. This differs from Beattie and Bradbury's procedure who allowed time to their subjects to compose a short story on a theme provided. The reasons for abandoning their procedure were twofold. First, initial results with their procedure showed that there was a very low rate of pausing in a group of subjects (none of whom were used here). Second, the spontaneous speech task is better suited to an anticipated practical application of this procedure (see the Discussion).

Subjects were told to speak for 3 min (Beattie and Bradbury only recorded 2 min). They were instructed that in the first phase of the experiment (the first two 3 min trials), performance would be assessed, but that they would receive no feedback on their speech. In the next phase, which extended for the next five trials, they were told their performance would be reassessed, but they would receive feedback. They were told this was provided by a red light that switches on when performance was judged to be poor. They knew that the more frequently the red light came on, the poorer the speech. In the last phase (last two trials), they were told their performance was reassessed without feedback. In all, nine 3-min trials were conducted with the first two and last two being without feedback about pausing. The subjects were not told that pausing controlled whether the light switched on or not (two realized pauses were controlling the light—subjects, Caleb and Guy and the other two did not).

Subject's speech was recorded, but reinforcement was not contingent on actual speech content. No reinforcement was delivered in baseline trials 1 and 2, or in extinction trials 8 and 9. The punisher (the light signifying "poor" performance) was contingent on the 600-msec unfilled pauses, on a full reinforcement schedule in trials 3-7. The tapes were transcribed by the second author who has had extensive experience with dysfluent speech and whose reliability with a second experienced judge is good as has been reported elsewhere (Howell, Sackin, & Glenn, 1997). The transcriptions noted types of fluency failure that includes segment, part-word, word, and phrase repetitions, segmental or syllabic prolongations, and filled pauses, as well as the silent pauses signalled by the voice operated switch. The latter, followed the definition given in Beattie and Bradbury.

RESULTS

Pauses

The number of pauses detected by the voice-operated switch (i.e., pauses 600-ms duration or greater) in a 3-min period was calculated for each session of each subject. These are shown for the separate subjects in Figure 1. For all subjects, the number of pauses in the first two sessions was higher than in any other session. Pause rate dropped abruptly in punishment sessions. The low pause rate showed some recovery in the last two sessions where no reinforcement was given for three subjects (Caleb, Paul, and Rob). The data were analyzed by ANOVA. The results for the nine sessions were coded as to whether they were before, after, or during punishment as one factor (the second factor was subject). Pause counts differed across conditions ($F_{2,24} = 79.5$, $p < 0.001$) supporting the changes noted in pause rate by session type. Subjects also differed ($F_{3,24} = 9.6$, $p < 0.001$). In Beattie and Bradbury's study, silent pauses returned to base line level during extinction trials, whereas the three subjects who showed some recovery showed a much reduced rate of silent pausing compared with baseline rate. It seems clear, however, that the operant procedure was effective at controlling silent pauses.

Filled pauses were obtained from the transcriptions. These were represented as percentage speaking time (percentage was used, as filled pauses can differ in duration, making a simple count statistic not appropriate). The percentages were analyzed in the same way as the counts of silent pauses. Individual results over sessions are shown in Figure 2. All subjects showed a reduction from baseline to conditioning sessions to some extent (this was least marked for Paul). When punishment was removed, filled pauses, unlike silent pauses, returned to around baseline rate for all subjects, except Guy. There was a significant difference across session type ($F_{2,24} = 3.77$, $p < 0.05$), supporting the change in incidence of filled pauses in the phases of the experiment. There were also significant differences across subjects ($F_{3,24} = 9.97$, $p < 0.001$). The importance of the reduction in filled pause rate, as well as silent pauses, is that it shows subjects did not respond to conditioning based on silent pauses by exchanging them for filled pauses. Beattie and Bradbury's (1979) did not report on filled pauses separately.

The experimental instructions were to maintain speech rate. Speech rate was calculated, including everything except silent pauses. Speech rates (in words per second) are shown for each individual subject across sessions in Figure 3. Three of the four subjects showed an increase in speech rate (the exception is Paul). Rate recovered when punishment was removed for two of the subjects who had shown a rate increase (Caleb and Rob) and Paul had a reduced rate when punishment was removed, although there is not firm evidence of a rate increase during conditioning. In a similar analysis to that on pauses, speech rates differed across session type ($F_{2,24} = 17.56$, $p < 0.001$) and speakers ($F_{3,24} = 69.4$, $p < 0.001$) and these two interacted ($F_{6,24} = 3.663$, $p = 0.01$). Beattie and Bradbury's reason for analyzing speech rate was to ensure that speakers did not lower speech rate to achieve this goal. They also found an increase in filled pauses that they attributed to an increased amount of repetition.

In the final analysis, repetition rate was determined separately on function and content words (phrase repetition, involving more than one word, were not included in this analysis). The data on total repetition rate and repetition rate, separated into function and content words, is given across sessions for individual subjects in Figure 4. Looking at content word repetitions first, for all subjects, rate was low and no change is apparent in nonconditioning sessions (baseline or after conditioning was withdrawn). This is also shown by the fact that overall repetition rate is highly correlated with function word repetition rate. Three of the four subjects show an increase in function word repetition rate over baseline in conditioning

sessions (the last one, Rob, showed some reduction). All subjects except Paul showed recovery in function word repetition toward baseline rates in the sessions after punishment was withdrawn (this was in the opposite direction for Rob to the others). For three of the subjects, the hypothesis that function word repetition rate will increase when pauses are removed is confirmed. For the subject who showed a reduction in function word repetition rate, two things are of note. First, this was not achieved at the expense of an increase in content word repetition rate, this remained low and constant across conditioning sessions. Second, this subject has a much higher rate of function word repetitions in baseline conditions compared with the other subjects (around three times higher). As he showed a reduction in silent and filled pauses and an increased speech rate in conditioning sessions, the reason for the reduction in function word repetition rate in conditioning sessions is not clear. This subject was left out of the ANOVA, because he showed different performance patterns. For the remaining three subjects, there was a significant difference across conditions ($F_{2,17} = 3.7$, $p < 0.05$). Note that although dropping this subject may appear unusual, typically, in conditioning experiments, the effects across subjects are often different and no cross-subject analyses are given (Beattie and Bradbury's study being a notable exception).

DISCUSSION

It was found that when discouraged from producing silent pauses in their speech, three of the four subjects increased the incidence of function word repetitions, but no repetition of content words was observed. The main question is why does preventing pausing specifically lead to an increase in proportion of word repetition on function, not content, words? Several alternative explanations for this are assessed below. The last explanation considered readily lends itself to address additional (more specific) questions about the role of function word repetition. Two such questions addressed are: How the particular type of fluency failure that emerges on function words (word repetition) has a similar role to silent pausing; why the form of fluency failure on function words is different to that which occurs on content words.

To begin with, a broad distinction may be drawn between two ways fluency failure could arise on function words There might be some context-independent, inherent characteristics of this word type that lead them to be more susceptible to fluency failure than content words. For example, the different roles the words have in an utterance, perhaps due to them being learned and utilized in different orders during language development, may lead to function words being more prone to fluency failure. The second alternative is that the fluency failures on function and content words are different forms of responding to fluency failure in a context extending beyond the word level that incorporates both lexical types (e.g., phonological words).

There are several psycholinguistic differences that have been reported between function and content words that need to be evaluated as contenders that might make one word class more prone to fluency failure than the other. First, function words occur more frequently than content words (Kucera & Francis, 1967). This cannot explain the increase in proportion of function words when pauses are prevented, however, since the more frequent function words would be expected to be less prone to fluency failure. This is shown, for example, by the fact that work on TOT states does not employ function words (Caramazza & Miozzo, 1997; Miozzo & Caramazza, 1997). Although this observation appears to rule out a frequency-of usage explanation, another possibility is that the frequency imbalance does not happen in the formative years where language is being established. In the one-word stage, only content words are used (Bloom, 1970; Brown, 1973; Radford, 1990). However, the one-word stage only lasts for a short time. Once speakers begin to produce connected speech, the usage of function words far outstrips that of content words. Thus, apart from very early language

experience, function words predominate right through speech development and beyond into adulthood. Thus, function words should be better learned and less likely to lead to fluency failure than content words. A third alternative is that function words carry less information than content words (Landau & Jackendoff, 1993). From this perspective, function words would be linguistically less exacting and, therefore, less error prone, whereas, in fact, they lead to more errors. The fourth possibility stems from the morphological differences between function and content words (Arnoff, 1976). However, as function words have a simpler morphological structure, this could not explain the disparity between word types in terms of incidence of fluency failure. Fifth, function and content words may be stored in different parts of the mental lexicon and accessed differently due to these encoding differences (Bock & Levelt, 1994; Levelt, 1992). It is not clear how differences in the way the word types are accessed should lead to function words having more of a problem than content words, particularly bearing in mind the simpler nature of function words noted earlier (such as, more frequent use).

There does not seem, then, a stand-alone characteristic of the two word types that can explain why more function word fluency failures (word repetitions) rather than content word failures occur when silent pauses reduce in frequency. The alternative type of theory is that the fluency failures on function and content words reflect different ways of dealing with difficult stretches of speech in a context that can include function and content words. Here phonological words (outlined in the introduction) will be considered as a contextual unit to locate groups of words where there may be one word (the content word) on which phonological difficulty is focused and the ramifications for patterns of fluency failure extend in and around this unit. When using phonological words for this purpose (as defined in the introduction), the function-content word distinction constitutes a convenient way of locating the phonologically difficult locus in this unit.

The higher complexity of content than function words is shown in analyses of the samples of spontaneous English speech used by Howell *et al.* (1999). This sample includes several different age groups of speakers who stutter and of fluent speakers. Of the function words used, 95% are monosyllabic and 99% carry no primary stress. Of the content words, 88% start with consonants whereas only 57% of function words do. Of content words, 14% start with consonant strings whereas only 1% of function words do, using Sander's (1972), definition of 'consonant string'. These properties remain roughly constant across normally fluent speakers and people who stutter ranging between 2 and 40 years.

Before the significance of the different patterns of fluency failure for theory can be considered further, the relationship between fluency failures and speech errors and the theories the latter evidence has spawned needs to be established. Errors obviously happen in speech but do so infrequently (support for this is the length of time a psycholinguist spends listening to speech to collect large enough corpora for analysis). Different patterns of errors can be distinguished that reveal the operation of two levels of speech planning. Word-based exchange errors arise at the lemma level and sub-word level speech errors involve phonemic or syllabic breakdowns and transmutations result from the phonemic level (see Dell, 1986 for a full description of error patterns associated with each of these levels). Fluency failures (such as function word repetition, starting a content word with the correct initial phone or phones, but then repeating or prolonging the first part, etc.) are not errors per se, as no wrong phones are produced. If the word form is not retrieved at the lemma level (as may occur occasionally on content words), repetition of a prior function can kick in, allowing time until the lemma is ready. A second type of fluency failure that occurs in this same circumstance is based on the assumption that the phonemic buffer fills up left to right (see Caramazza & Miozzo, 1997; Miozzo & Caramazza, 1997 for support for this view from TOT studies). Commencing saying a word before the output buffer is complete results in a

form of fluency failure involving the initial phones alone. Note that since the output buffer continues filling up during time for execution, speech will be fluent when speech is initiated before the output buffer is full, on some occasions. In addition to the two components involved in preparing speech for output, an independent execution stage is also required. An independent level responsible for execution of speech allows the planning process to continue while execution of a previous word is going on (Clark & Clark, 1977).

According to this account, the time at which execution of a previously planned word (word *n*-1) is completed determines when the plan for the next word (word *n*) is required. In this sense, execution time for preceding words taxes the planning process by accelerating when the next plan is needed. Planning may take place several words in advance of the current one, as the speech error literature shows (Dell, 1986). In situations where fluency failure occurs, however, the relationship between the word just executed and the plan of the next one, alone is vital. At these points, forward planning does not extend beyond the next word to be produced. This state can lead to fluency failures when a speaker has finished executing word *n*-1 and the plan for word *n* is not ready. The speaker has several options of how to deal with this (one of which is function word repetition) that reflect fluency failure around these points.

The extent of the contexts that are likely to lead to plans being available (fluent) or not (fluency fails) need specifying. Ordinarily, the plan is available prior or immediately after a preceding word has been executed, and, thus, speech is fluent (appropriate handshaking has occurred between execution of word *n*-1 and planning of word *n*). This handshaking usually applies because planning is rapid relative to execution. [See Sternberg *et al.* (1978) for evidence for rapid planning of sequences when the words comprise a well-learned small set of everyday words i.e. days of the week.]

If the current word takes a short time to execute, the plan of the next one needs to be available more rapidly than in situations where the current word is executed slower. The relative difficulty on function and content word types indicates the circumstances in which the plan of the subsequent word is not going to be available when the preceding one has finished being executed. This is most likely to happen when there is little advance planning (a hand-to-mouth state), a function word (short, involving few consonant strings, no difficult consonants, and carrying no stress), is executed rapidly and is immediately followed by a word that is time consuming to plan at lemma and/or phonemic output levels. Note that producing a comparatively easy function word itself does not necessarily lead to the plan for the subsequent word not being ready. If the following word is simple and quick to plan (e.g., another function word), it will be available in time. Only when the following word is complicated to generate is it likely to require a longer planning time that can lead to fluency failure. There are two main factors that lead to the planning of a content word requiring more time: (a) Content words may take a long time to retrieve (lemma level) if the frequency of usage of the word is low (Wingfield, 1968); and (b) it is also possible that content words will take more time to plan at the phonemic level when they include long and complex phonemic strings. When a content word contains such complex strings, phonemic output for these parts of words will also take longer to execute than the simpler stretches.

On the occasions that planning of a word is not complete by the time the preceding word has finished being executed, the speaker may delay execution of the next word. One option that would deal with this situation is to re-execute a previously planned word. Planning for the next word can continue (in the way described earlier) until its plan is complete. According to this account, if function words are repeated, dysfluency on content words will largely be avoided, explaining why there is the imbalance between fluency failures on different word types. The inherent redundancy when repeating a function word delays the point in time

when the problematic content word has to be produced. In a sense, the running off the prepared plan slows speech to allow more time for the unprepared content word. This has obviously similarities with the role ascribed pauses (Butterworth, 1975; Goldman-Eisler, 1972). According to the account, if function words are not repeated, all the plan of the content word is not available. What will be available is the early part as phone output is built up left-to-right. Dysfluencies on content words will, then, involve repetition, hesitation, or prolongations of these phones. Dysfluencies on content words are usually avoided in fluent speakers by using function word repetition. Adults who stutter use proportionately fewer function word repetitions (Howell *et al.,* 1999). Conversely, they attempt content words before the plan is ready proportionately more often (Howell *et al.,* 1999). This contextual account, unlike accounts based on the lexical class alone, provides an explanation of the similarity between silent pausing and function word repetition and why forms of fluency failure have different forms on the two word types.

These findings lead to a potential practical application with people who stutter. Adult stuttering (as just noted, happening predominantly on content words) is notoriously intractable to treatment, unlike childhood stuttering, which has a high rate of function word repetitions. Our work suggests that if function word repetition could be reinstated, content word failures should disappear. This follows from the earlier account since fluency failure either occurs on function words or on content words (see Howell *et al.,* 1999 for corroboratory evidence). Operant conditioning techniques are currently widely employed with people who stutter (Onslow *et al.,* 1997). The form of these treatments is to prevent stuttering by timing the speaker out when they produce fluency failures. No guidelines are given about what stutterings to target. It may be assumed that practioners attempt to time out (a) all types of stutterings and (b) every one that occurs. Considering (a) first, the reciprocal relationship between function and content word fluency failures (Howell *et al.,* 1999) suggests that it may only be necessary to target one type of word—just punishing (and presumably reducing the incidence of) content words by time out should increase the proportion of function word repetitions. Alternatively, encouraging function word repetitions by preventing pausing should decrease content word fluency failures. Considering (b), the partial resistance to extinction effect observed in conditioning studies, suggests that a less than 100% reinforcement rate may allow the therapeutic gains to be maintained long term. These possibilities for treatment remain to be explored.

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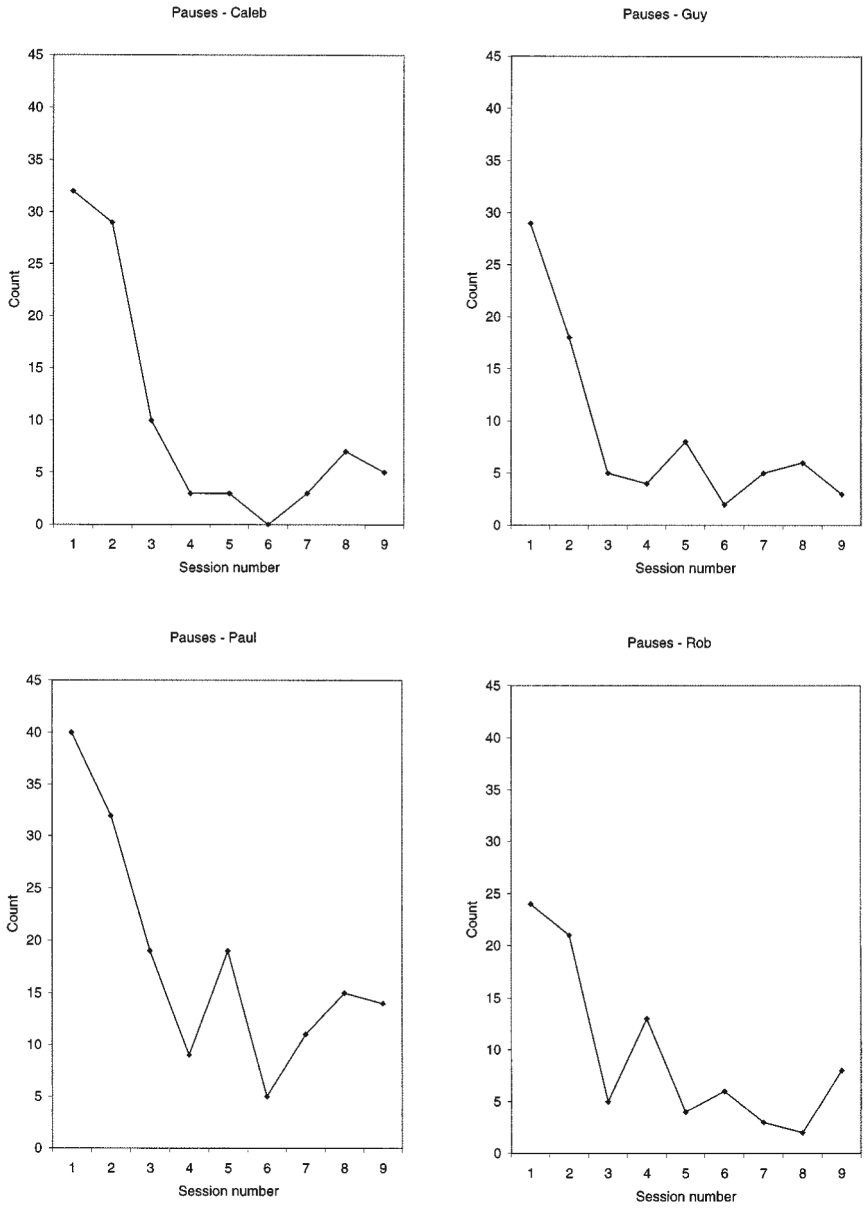

Fig. 1.
Silent pause count (ordinate) versus session number (abscissa) for the four subjects who performed the experiment. No punishment was given in sessions 1 and 2 and 8 and 9.

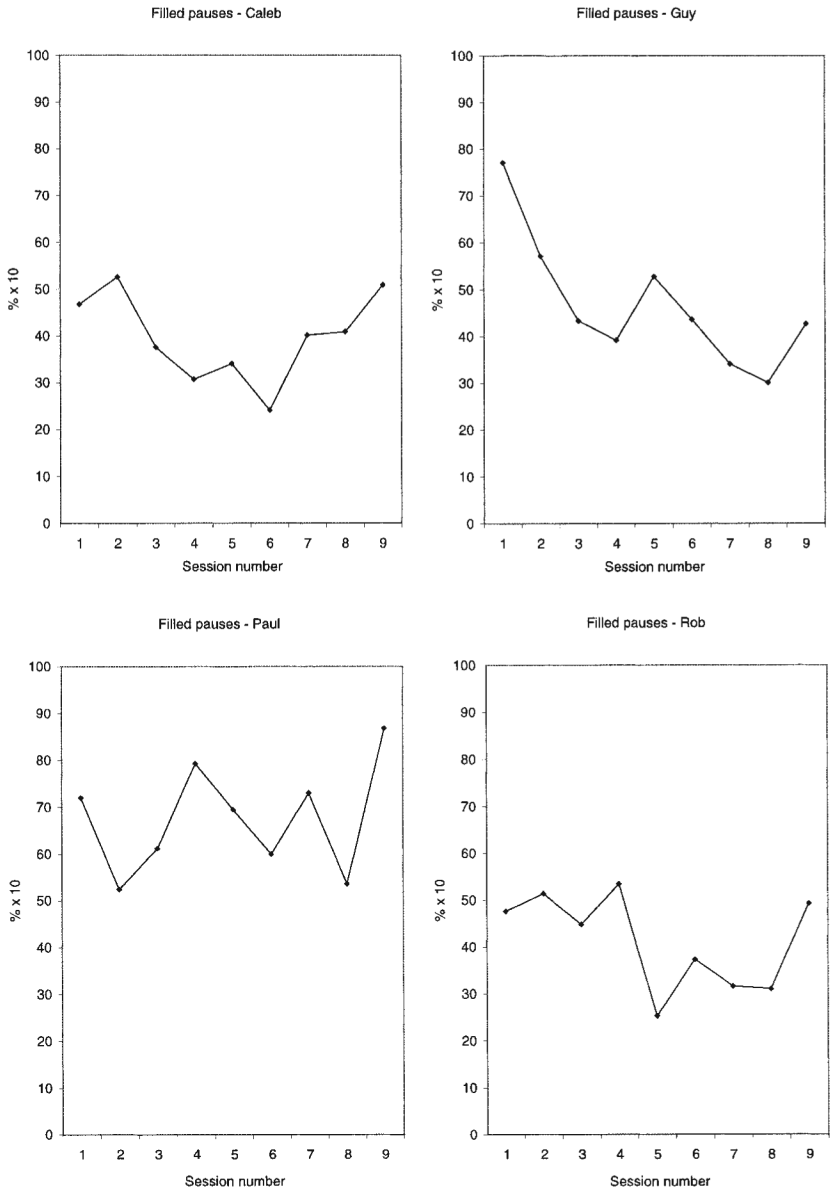

Fig. 2.
Filled pause as percentage of all speech (ordinate) vs. session number (abscissa) for the four subjects who performed the experiment. No punishment was given in sessions 1 and 2 and 8 and 9.

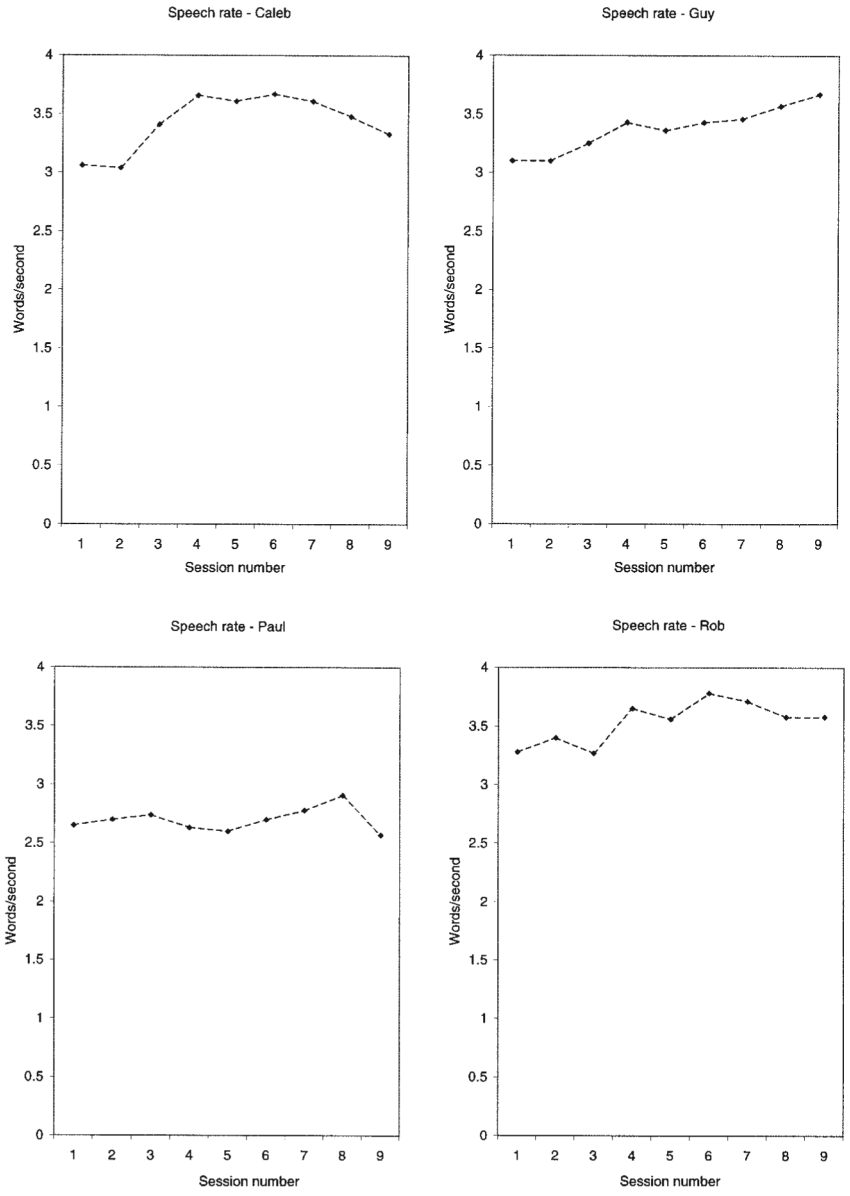

Fig. 3.

Speech rate in words per second after silent pauses were removed (ordinate) vs. session number (abscissa) for the four subjects for the four subjects who performed the experiment. No punishment was given in sessions 1 and 2 and 8 and 9.

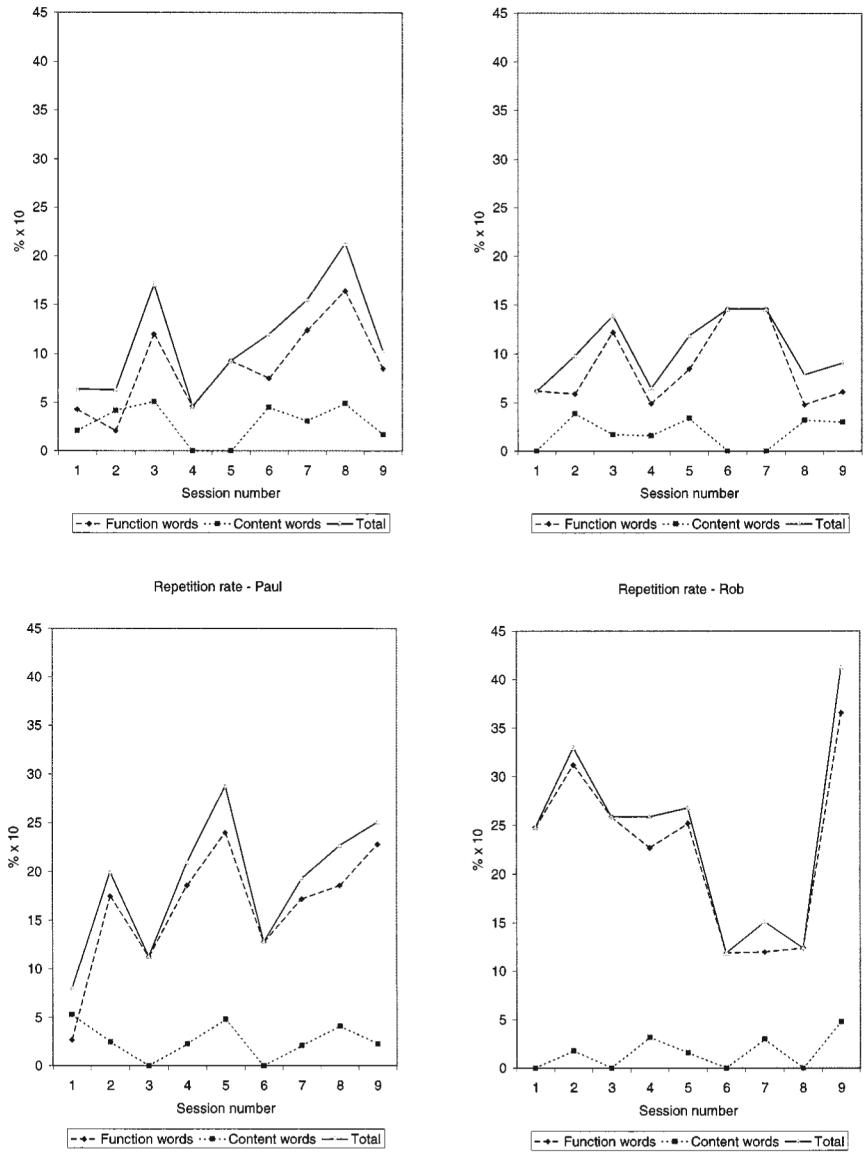

Fig. 4.

Total word repetition rate, function word repetition rate, and content word repetition rate all as percentages of speech time (ordinate) vs. session number (abscissa) for the four subjects who performed the experiment. The three repetition rates can be identified by the caption at the foot of each panel. No punishment was given in sessions 1 and 2 and 8 and 9.

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