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Listening while Talking: The Retention of Prose under Articulatory Suppression in relation to Simultaneous Interpreting¹

6.1 Introduction

It is well established that short-term memory for words is disrupted when participants continuously articulate irrelevant material, such as “the, the, the, ...” during the presentation of the to be remembered words (e.g., Baddeley et al., 1984; Murray, 1968). This so-called articulatory suppression effect can be readily explained in the working memory model of Baddeley and colleagues (Baddeley, 1986, 2000; Baddeley & Logie, 1999; Gathercole & Baddeley, 1993). According to this model, working memory is a general purpose short-term memory system, which is involved in the temporary processing and storage of information. The model consists of three components, the central executive and its two slave systems, the visuospatial sketchpad and the phonological loop. The central executive is a supervisory system involved in the control and regulation of the working memory system. Its functions comprise coordination of the two slave systems, focusing and switching attention, and activating representations in long-term memory. The visuospatial sketchpad is assumed to hold information about objects and locations. The phonological loop is specialized in the storage of verbal material.

The phonological loop is hypothesized to comprise two dissociable subcomponents, a passive phonological store and an active subvocal rehearsal system. The phonological store maintains representations of speech-based coding which are assumed to decay over a period of about two seconds. A process of articulatory rehearsal serves to refresh the decaying representations. This process is also required to transform non-phonological inputs, such as visually presented words or pictures, into their phonological form. Speech material, in contrast, does not need any recoding but is believed to gain obligatory access to the phonological store.

Evidence on the nature of the loop comes in particular from four phenomena (see Baddeley, 2000; Baddeley et al., 1984; Baddeley & Logie, 1999; Gathercole, 1994;

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Gathercole & Baddeley, 1993). The first is the finding that similar sounding items are harder to remember than dissimilar items. This *phonological similarity* effect is assumed to occur because items are stored in a speech-based code. Similar items have fewer distinguishing features and hence are more subject to error (e.g., *cat, rat, man*, versus *man, egg, boat*). Second, the effect of *irrelevant speech* entails that when participants hear continuous irrelevant speech during presentation of words to be memorized, their recall is disrupted. Spoken material gains automatic access to the store and therefore interferes with the phonological representations of the items to be remembered. These two effects are attributed to the phonological store, whereas the locus of next two phenomena is believed to be the articulatory rehearsal process. The *word length effect* concerns the finding that fewer words are remembered when words are long than when they are short in articulatory duration (e.g., *opportunity* versus *wit*). Because subvocal rehearsal in the phonological loop is supposed to take place in real time and long words take longer to articulate than short words, the refreshment rate of these items in the store is lower, and hence fewer items can be recalled. Finally, the fourth finding concerns the effect of *articulatory suppression* (AS). As mentioned earlier, memory performance drops substantially during AS. The disruptive effect of articulation is assumed to arise because it prevents participants from subvocal rehearsing. AS abolishes any effects of phonological similarity or of irrelevant speech when memory items are visually presented. Moreover, it removes the word length effect in both visual and auditory presentation, presumably because this effect relies on rehearsal (e.g., Baddeley et al., 1984; Longoni, Richardson, & Aiello, 1993). In other words, AS, or the articulation of speech, disrupts recall of simultaneously presented material.

A task that naturally involves language production during processing of language input is simultaneous interpreting (SI). In SI spoken input is immediately translated from the input or source language to the output or target language. It is found that retention of a spoken text after simultaneous interpreting is worse than after just listening to it (Christoffels, 2003a, Chapter 7; Darò & Fabbro, 1994; Gerver, 1974b; Isham, 1994; Lambert, 1988). A possible reason for the reduced recall in interpreting is that the production of speech interferes with retention of input (see also Christoffels & De Groot, in press, Chapter 2; Isham, 2000). In other words, reduced recall in simultaneous interpreting can possibly be explained by the notion that in SI a situation arises that resembles articulatory suppression.

Obviously, there are a number of differences between producing meaningless sounds and producing an interpretation of a text. A crucial difference between simultaneous interpreting and a typical articulatory suppression condition is the type of material that has to be retained. Interpreting typically involves larger text units, rather than single words. The effect of articulatory suppression has typically been reported for recall of lists of words (e.g., Baddeley et al., 1984). However, due to chunking more words tend to be remembered when they form a sentence than when they are unrelated. Also more sentences are remembered when the sentences form a narrative (Baddeley, 2000).

The goal of the first experiment was to establish whether the detrimental effect of AS on recall generalizes to auditorily presented stories rather than single words. Although an

effect of phonological interference in simultaneous interpreting appears to be a very straightforward explanation of the relatively low retention after interpreting, it seems that the existence of an effect of AS on narratives is a prerequisite to such an explanation.

In the second experiment we explored the relation between recall under AS conditions and SI performance. The ability to maintain information during speech production (i.e., the ability to resist the detrimental effects of phonological interference) may be one of the skills underlying successful SI. This is suggested by findings of Padilla, Bajo, Cañas, and Padilla (1995), and Bajo, Padilla, and Padilla (2000). They observed that, although interpreters, non interpreters, and students of interpreting performed alike on a word span task, unlike the other groups, the interpreters did not suffer a decrement in recall under conditions of AS.

We assessed the relevance of AS to SI by investigating the relation between individual differences in how well participants are able to retain information under AS conditions on the one hand (i.e., to resist the detrimental effect of AS on recall) and their SI performance on the other hand. The results are discussed within the working memory framework, and focus on the recently proposed addition to this model, the episodic store (e.g., Baddeley, 2000).

6.2 Experiment 1

The goal of Experiment 1 was to establish whether there is any effect of AS on retention of short stories. An important difference between lists of words and retention of short stories is that a story has an internal structure, which may improve recall. To assess the effect of story structure we presented both normal and scrambled versions of the stories. By simply changing the order of the sentences we destroyed the coherence of the story.

Other than the type of the material to be remembered, standard articulatory suppression on the one hand, and simultaneous interpreting on the other hand, differ in the meaningfulness of what is being uttered. AS is purposefully meaningless, whereas evidently the output in SI carries semantic content. We manipulated the meaningfulness of the articulatory suppression condition by presenting both a standard articulatory suppression condition, in which participants uttered irrelevant sounds, and a meaningful articulatory suppression condition in which participants uttered a sequence of three words. Obviously, the role of meaning in the latter condition is still rather minimal and the meaning of the words uttered is unrelated to the stories the participants listened to. So, if this manipulation has an effect then, clearly, the content of the articulation that the participants engage in is important.

We hypothesized that the articulatory suppression effect normally found in recall of words generalizes to stories. In other words, we expect that articulatory suppression will negatively affect retention in comparison to a control condition in which no articulatory suppression takes place. Moreover, meaningful AS may have an even larger effect on recall, because the utterance of lexical items would activate these irrelevant items and their

meaning. Furthermore, we expect that recall in the coherent conditions will be larger than in the incoherent condition and we will explore the interaction between this factor and AS.

6.2.1 Method

Participants

Thirty Dutch university students participated in this study. Their average age was 21.2 years. The data of one participant was excluded from analysis because of extremely poor performance in the easiest condition, and replaced with another participant to complete counterbalancing. All participants received course credit for participation.

Material

Nine different Dutch stories were written for this study. Three of these were used for practice only. The stories were read aloud by a female speaker and digitally recorded by computer. The stories were between seven and nine sentences long and consisted on average of 85 words. The recordings were on average 30.8 seconds. From the audio recordings of the six experimental stories, six incoherent stories were constructed by randomly changing the order of the sentences in each story (e.g., Thorndyke, 1977). The incoherent story never started with the first sentence of the coherent story and the order of two sentences was never the same as in the coherent stories (e.g., sentence 5 never followed sentence 4). In Appendix 7 a coherent and an incoherent version of one of the stories is presented. Each story was constructed such that it consisted of 50 items, i.e., minimal information units mainly corresponding to single words, except for articles and prepositions that formed an item together with their related element.

Design and procedure

Two factors were manipulated within subjects, AS condition (No-AS, AS, M-AS) and coherence of the story (coherent and incoherent). No-AS was the control condition in which the participants just listened to the recordings of the stories. During AS, participants uttered 'de, de, de' continuously while listening, and during the meaningful AS condition (M-AS) the participants uttered 'hond, kat, muis' (*dog, cat, mouse*) continuously while listening.

The order of stimuli and conditions was counterbalanced across participants. Every story was presented in both the coherent and the incoherent condition and equally often in each AS condition. Furthermore, AS conditions were equally often presented first, second or third. The coherent and incoherent conditions were presented in blocks in counterbalanced order: Half of the participants started with the coherent condition, the other half started with the incoherent condition.

Before the start of an AS condition, the participants received instructions and practiced the condition with one of the (coherent) practice stories. In the practice session, the

experimenter checked whether the tempo of articulation was reasonable fast and encouraged faster articulation if necessary.

The stories were presented auditorily over headphones. First, an alert sounded, then 3 s. later the story was presented. A second alert indicated that the story was finished. After 20 s. the third and last alert sounded, indicating that the participants should stop articulating and start recalling the story. In other words, the participants carried on articulating until 20 s. after the story was finished. The participants were instructed to write down as much as they could remember of the stories and try to recall the stories in exact wording. After 3 minutes a final alert sounded to indicate that the maximum recall time was reached. Almost all participants needed less time than the three minutes allowed. Each session took about 40 minutes.

6.2.2 Results and discussion

For each participant the percentage of recalled items was calculated. Each of the 50 items had to be reproduced exactly in the written free recall to be considered correct.

A repeated-measures ANOVA was performed with AS condition (No-AS, AS, M-AS) and coherence (coherent, not coherent) as within-subject factors. Significant main effects for AS condition, $F(2, 28) = 12.37, p < .001, \eta^2 = .47$, and for coherence, $F(1, 29) = 40.55, p < .001, \eta^2 = .58$, were obtained. Consistent with our expectations, recall performance was much better for coherent stories than for incoherent stories. The main effects were qualified by a significant interaction between AS condition and coherence, $F(2, 28) = 3.59, p = .041, \eta^2 = .20$. In Table 1, the average recall percentages per condition are presented.

Table 1. Mean percentage recall (% recall) and standard deviation (SD) per condition.

		AS condition		
		No-AS	AS	M-AS
Coherent	% recall	64	57	49
	SD	12	13	17
Incoherent	% recall	49	46	44
	SD	12	14	16

Note. No-AS: control condition; AS: articulatory suppression; M-AS; meaningful articulatory suppression.

The average percentage recall per condition is also graphically presented in Figure 1. It shows that the effect of AS condition is much larger for the coherent stories than for the incoherent stories.

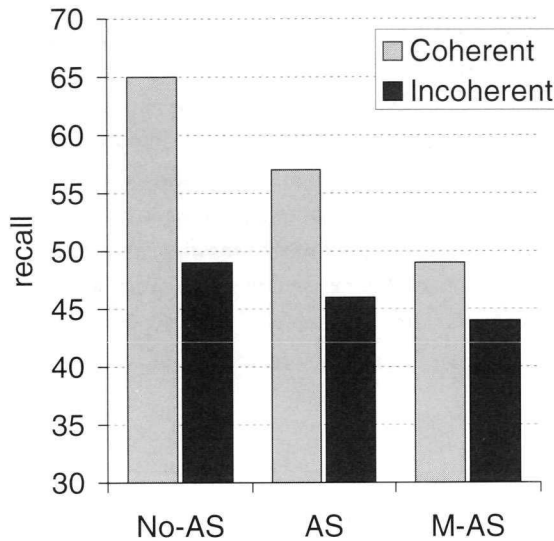


Figure 1. Mean percentage of recall per AS condition and per coherence condition (No-AS: control condition; AS: articulatory suppression; M-AS: meaningful articulatory suppression).

Effects of AS

Inspection of Figure 1 indicates that the AS conditions influenced performance, but that this task manipulation was far less effective in the incoherent condition. Simple main effects analyses showed that in the coherent condition recall was reduced in both the AS condition, $F(1, 29) = 7.27, p = .012, \eta^2 = .20$, and the meaningful-AS condition, $F(1, 29) = 26.27, p < .001, \eta^2 = .48$, as compared to the no-AS control condition. In other words, conditions of AS reduced recall of the stories. The difference between the AS and the meaningful-AS condition was also significant, $F(1, 29) = 4.49, p = .043, \eta^2 = .13$, indicating that the latter type of articulatory suppression even reduced recall further.

In contrast, in the incoherent condition, none of the AS-conditions differed from each other significantly, no-AS vs. AS: $F(1, 29) = 1.30, p > .10, \eta^2 = .04$, and AS vs. M-AS: $F(1, 29) < 1, p > .10, \eta^2 = .03$, although the difference between no-AS and meaningful-AS was marginally significant: $F(1, 29) = 3.44, p = .074, \eta^2 = .11$.

Effects of Coherence

Figure 1 shows that the effect of coherence depended on AS condition. Simple effects analyses revealed that the effect of coherence was significant in the No-AS and AS conditions, $F(1, 29) = 39.66, p < .001, \eta^2 = .58$, and $F(1, 29) = 14.33, p < .001, \eta^2 = .33$, respectively, but not in the meaningful-AS condition, $F(1, 29) = 2.37, p > .10, \eta^2 = .08$.

As expected, articulatory suppression negatively affected retention of short stories. Interestingly, the effect of AS is modulated by the coherence of the stories. From Figure 1 it is clear that the AS manipulation was far less effective in the incoherent condition. Evidently, in the control condition, without any concurrent articulation, the participants are able to use the story structure to help retaining the story. Under AS the advantage of a story structure decreases, especially when meaningful AS is required, where the difference between the coherent and incoherent condition does no longer reaches significance. When the coherence of the story is removed by changing the sentence order, the additional negative effect of AS on recall is very small. Nevertheless, note that even under the most difficult recall condition recall is not at floor level.

We also obtained a difference between standard and meaningful AS in the coherent condition. Although it is not completely clear how this difference should be explained, it clearly suggests that the type of articulation that a participant engages in affects recall. It has long been known that phonological loop performance is influenced by long-term knowledge about language. This is indicated, for example, by the lexicality effect, which involves better recall for real words over nonwords (e.g., Gathercole, Pickering, Hall, & Peaker, 2001), and the finding that nonwords that are high degree of rated wordlikeness result in better immediate recall than nonwords that are not (Gathercole, 1995; Gathercole, Willis, Emslie, & Baddeley, 1991). Articulation of different real words (i.e., in the meaningful-AS condition) rather than repetitive sounds (i.e., in the AS condition) will activate the lexical and conceptual representations of these words in long-term memory. Possibly, this activation interferes when retaining information, in addition to blocking the rehearsal process, as does the repetition of meaningless sounds. Alternatively, the difference between the AS and meaningful-AS conditions lies not in the meaning of the words but is due to the fact that it is more effortful to repeat different words than is repetition of one and the same sound. So, possibly, articulation in the meaningful-AS condition takes up more central resources, which may interfere with recall.

6.3 Experiment 2

In Experiment 2 we explored the relation between how well participants retain stories under conditions of AS on the one hand, and how well they perform on an interpreting task on the other hand. As mentioned earlier, there is some evidence that professional interpreters may be differentiated from other groups of participants in their ability to negotiate the disrupting effects of AS (Bajo et al., 2000; Padilla et al., 1995). Possibly, the ability to retain information under conditions of AS is important for successful SI. We therefore assessed SI performance by asking participants, who never had attempted to simultaneously interpret before, to interpret an English text (the second language; L2) into Dutch (the native language, L1). We correlated SI performance with the data on retention under the different AS conditions from Experiment 1. Especially in the meaningful-AS condition a positive

correlation between recall and SI may be expected because in this condition recall is measured under an AS condition that resembles SI most.

6.3.1 Method

Participants

The participants of Experiment 1 also participated in this study. All participants were native speakers of Dutch and spoke English as a second language. On a scale from 1 (no knowledge) to 10 (native-like knowledge), the participants rated their active knowledge of English on average 7.4 and their passive knowledge on average 7.8.

Material

One English text was used for a practice session and one for the experimental session. The practice session text consisted of a one minute recording taken from a medium level English listening high school exam in the Netherlands. The experimental SI task-recording was 4.2 minutes long. It concerned a text on the science of face perception (see Appendix 6). The recorded text was spoken by a native speaker of English at a rate of 116 words per minute.

Design and procedure

After participating in Experiment 1, the participants were asked to translate the English text as well as possible into Dutch and to start translating while listening. The practice and experimental texts were presented auditorily to the participant over headphones. They were told that they should try to translate the meaning of what they heard rather than translate literally. The interpreting output of the participants was recorded on computer. The practice session preceded the experimental session. Each session took about 10 minutes.

6.3.2 Results and discussion

The interpreting performance of the participants was scored using the audio recordings of their interpretation. In all, 17 sentences, taken from the middle of the text, were rated between zero and three on how much of the source text sentence was correctly translated into Dutch (maximum score 51). The correlation was calculated between SI performance on the one hand, and recall in the No-AS, the AS, and the meaningful AS (M-AS) conditions on the other hand. Recall scores were taken from Experiment 1, but collapsed on the two levels of the factor coherence because this factor was not of interest in the current analysis. The correlations are presented in Table 2. As expected, recall under AS correlates positively with SI performance. However, only the correlation between SI and meaningful AS reaches significance. This is, however, the condition in which the strongest relation was expected. Although this correlation is only moderate, it provides some indication that even in

bilinguals untrained in SI the ability to retain information while producing speech may be a relevant subskill of SI.

Table 2. Correlations (r) between SI performance and recall in each of the AS conditions, and their associated p -values.

		AS condition		
		No AS	AS	M-AS
SI performance	r	.23	.26	.38
	p	.12	.07	.02

Note. No-AS: control condition; AS: articulatory suppression; M-AS; meaningful articulatory suppression.

6.4 General discussion

The main conclusion from Experiment 1 is that articulatory suppression negatively affects retention of short stories. This finding provides indirect support for the notion that relatively poor recall in interpreting in comparison to listening can be (partly) explained by the interference of speech production on retaining information.

The relevance of recall during AS for interpreting was indicated in the second experiment by a positive correlation between recall under conditions of meaningful AS and SI performance. The latter result suggests that individual differences in the ability to retain information under conditions of AS are associated with individual differences in performing an SI task without any previous experience in SI.

A recent revision of the working memory model discussed in the introduction (Baddeley, 2000; see also Baddeley, 2003) seems particularly relevant for our study, since we considered recall of short stories. One of the main reasons for revising the model was the difficulty the original model had in accounting for the temporal storage of material that clearly exceeds the capacity of the phonological loop. In particular the finding that recall of words is superior when they can be meaningfully chunked in a sentence and the large amount of information that is usually retained in immediate recall of prose passages needed to be accounted for. Therefore, a new component was added to the model: the episodic buffer. This buffer is assumed to be a limited capacity system that is capable of integrating information from a range of sources into a single complex coherent structure or episode. It heavily depends on executive processing but differs from the central executive in that it is principally concerned with storage of information rather than with attentional control. Evidence for the episodic buffer comes from densely amnesic patients who show normal immediate prose recall but poor delayed prose recall, suggesting that immediate recall of prose cannot completely be attributed to long term memory (Baddeley & Wilson, 2002). Figure 2 depicts the revised working memory model.

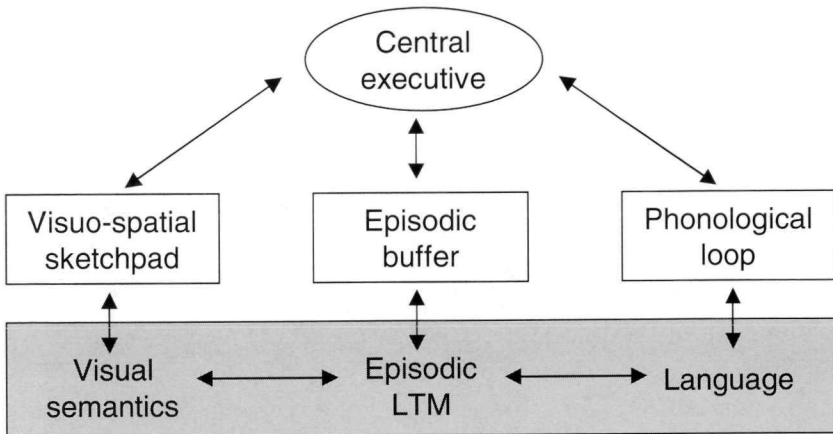


Figure 2. The revised model of working memory, including the episodic store (Baddeley, 2000). Shaded areas represent crystallized systems (capable of accumulating long-term knowledge), unshaded areas are fluid systems (attention and storage).

According to recent theory then, for recall of prose especially the episodic store is important rather than the phonological loop. However, theoretically, AS specifically affects the articulatory rehearsal process in the phonological loop. Nevertheless, we found an effect of AS on story recall, which was attenuated when story structure was removed. Do our results therefore indicate that the loop plays a significant role, by activating long-term memory, in using global story structure for story retention after all? Or do they indicate that the suppression technique influences this new component of the working memory system as well as the phonological loop? Neither possibility is very satisfactory and seems to contradict recent theoretical proposals.

Our results can, however, be explained in a way that quite naturally fits in the revised working memory model. As yet, the exact relation between the phonological loop and the episodic buffer remains unclear and no detailed account of transfer of information from the store to the new buffer is given. It is a reasonable assumption that building an episodic structure takes some time and that input is represented first in the phonological loop. AS can be assumed to only block the rehearsal process in the loop and is not supposed to require much attentional processing. If AS interferes with retaining information in the loop even before a structure can be fully built and maintained in the episodic store, an effect of AS on story recall would be expected. In other words, when an input trace in the phonological loop is more stable because it can be rehearsed, as is the case in the no-AS control condition, then structure building in the episodic store is more likely to be successful than under conditions of AS. If there is no structure to start with, as in the incoherent condition, this structure does not assist in building an episodic structure, making it more difficult to maintain information

in the episodic buffer. Hence, when the trace of the input is not refreshed this has less consequences for recall and therefore recall is likely to be more similar across the three AS conditions.

This account of our data has an interesting implication. If AS indeed partly prevents information from transferring from the loop to the buffer than we can predict that even comprehension, not only retention, should be reduced. The reason is that articulatory suppression interferes with building the episodic structure of prose. But, perhaps some (groups of) individuals are faster than others in transferring information from the phonological loop to the episodic buffer by building an episodic structure. Remember that it is not the phonological store that AS tampers with, it is the rehearsal process that is blocked. Professional interpreters, for example, may excel in how quickly they are able to complete transfer. This would emerge in the data as a resistance to the effects of AS (as is found by Bajo et al., 2000; Padilla et al., 1995). Also, individuals who are relatively fast in transferring information to the buffer, may have an advantage when trying to simultaneous interpret, resulting in a correlation between the two, as we found in Experiment 2.

The episodic buffer as a component of the working memory model may help in understanding memory processes in SI. The processing of new input and reformulation of the input into another language proceed simultaneously and both seem to need some sort of verbal buffer. This appears to exceed the capacity of the phonological loop. With the episodic buffer in place, we can assume that new input is temporarily stored at the loop, after which further processing of this input leads to a representation in the episodic store, freeing space for new input to be temporarily maintained in the phonological loop.

