



Universiteit  
Leiden

The Netherlands

## **Listening while talking; The retention of prose under articulatory suppression in relation to simultaneous interpreting**

Christoffels, I.K.

### **Citation**

Christoffels, I. K. (2006). Listening while talking; The retention of prose under articulatory suppression in relation to simultaneous interpreting. *European Journal Of Cognitive Psychology*, 18, 206-220. Retrieved from <https://hdl.handle.net/1887/14222>

Version: Not Applicable (or Unknown)

License: [Leiden University Non-exclusive license](#)

Downloaded from: <https://hdl.handle.net/1887/14222>

**Note:** To cite this publication please use the final published version (if applicable).

## **Listening while talking: The retention of prose under articulatory suppression in relation to simultaneous interpreting**

Ingrid K. Christoffels

*University of Amsterdam and Maastricht University, The Netherlands*

According to working memory theory (e.g., Baddeley & Logie, 1999) articulatory suppression (AS) prevents rehearsal in the articulatory loop of to be remembered material, which, in turn, has a disruptive effect on recall. Simultaneous interpreting is an activity where people routinely comprehend and maintain speech while articulating at the same time. We examined whether AS also affects retention when, as in interpreting, coherent text is to be remembered or meaningful and phonologically more complex material is articulated. In the first part of the study, participants listened to a set of stories, and were involved in traditional or complex AS. Also coherence of the texts was manipulated. We found that the effects of AS generalises to stories, that coherence influences recall and that both variables interact. In the second part, we related individual differences in retention under conditions of AS to simultaneous interpreting performance. The results are discussed in terms of the episodic buffer component (e.g., Baddeley, 2000).

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, Lewis, & Vallar, 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

---

Correspondence should be addressed to Ingrid Christoffels, Maastricht University, Faculty of Psychology, Department of Neurocognition, PO Box 616, 6200 MD Maastricht, The Netherlands. Email: i.christoffels@psychology.unimaas.nl

The author is grateful to Arnout Koornneef for research assistance and useful discussions and to Hilde Geurts, René Zeelenberg, Annette de Groot, and two anonymous reviewers for helpful comments on earlier versions of this paper.

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 specialised in the storage of verbal material.

The loop is hypothesised 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 2 s. A process of articulatory rehearsal serves to refresh the decaying representations. This process is also required to transform nonphonological 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; 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 memorised, 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 the 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 rehearsing subvocally. 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. SI is a cognitive complex task in which many processes take place at one moment in time. Segments of the source language have to be comprehended and stored. At the same time, earlier segments have to be transformed from source to target language and even earlier segments have to be produced in the target language (e.g., Christoffels & de Groot, 2005; Padilla, Bajo, Cañas, & Padilla, 1995). SI places high demands on working memory. For one, there is always a gap between the moment of input and output that has to be bridged by the interpreter. This so called ear-voice span usually averages at 2 s or about five words (Christoffels & de Groot, 2004; Gerver, 1976; Treisman, 1965). Moreover, it appears that professional interpreters command exceptional working memory resources (Bajo, Padilla, & Padilla, 2000; Christoffels, 2004) and for nonprofessionals a relation was found between memory and interpreting skills (Christoffels, de Groot, & Waldorp, 2003).

Interpreters do appear to take advantage of speech pauses in the source input (Barik, 1973; Goldman-Eisler, 1972, 1980). Nevertheless, a comparison of the speech input to their spoken output suggests that almost 70% of the time they are indeed speaking while processing the input (Chernov, 1994).

It is found that retention of a spoken text after simultaneous interpreting is worse than after just listening to it (Christoffels, 2004; Darò & Fabbro, 1994; Gerver, 1974; 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, 2005; 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 part of the study was to establish whether the detrimental effect of AS on recall generalises 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 part of the study 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 et al. (1995), and Bajo et al. (2000). They observed that, although interpreters, noninterpreters, and students of interpreting performed alike on a supra span word recall 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).

## PART 1: ARTICULATORY SUPPRESSION AND PROSE

The goal of the first part of the study 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 and (phonological) complexity of what is being uttered. AS is purposefully meaningless and simple in structure; it usually contains just one syllable. Evidently the output in SI carries semantic content and is more complex. We manipulated the complexity of the articulatory suppression condition by presenting both a standard articulatory suppression condition, in which participants uttered irrelevant sounds, and a complex 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 and the complexity of the articulation that the participants engage in is important.

We hypothesised that the articulatory suppression effect normally found in recall of words generalises 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, complex AS may have an even larger effect on recall, because the utterance of lexical items would

activate these irrelevant items and their meaning. Also, the production of three different words might be more effortful than the repetition of one syllable. 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.

## 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 s. From the audiorecordings 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; see Appendix). 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 the incoherent stories, therefore, global story structure was removed. Note that to some extent structure was still present in the material because the sentences were left intact. 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, C-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 complex AS condition (C-AS) the participants uttered “hond, kat, muis” (*dog, cat, mouse*) continuously while listening.

The order of the stories 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 par-

ticipants 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 to try to recall the stories in exact wording. After 3 min a final alert sounded to indicate that the maximum recall time was reached. Almost all participants needed less time than the 3 min allowed. Each session took about 40 min.

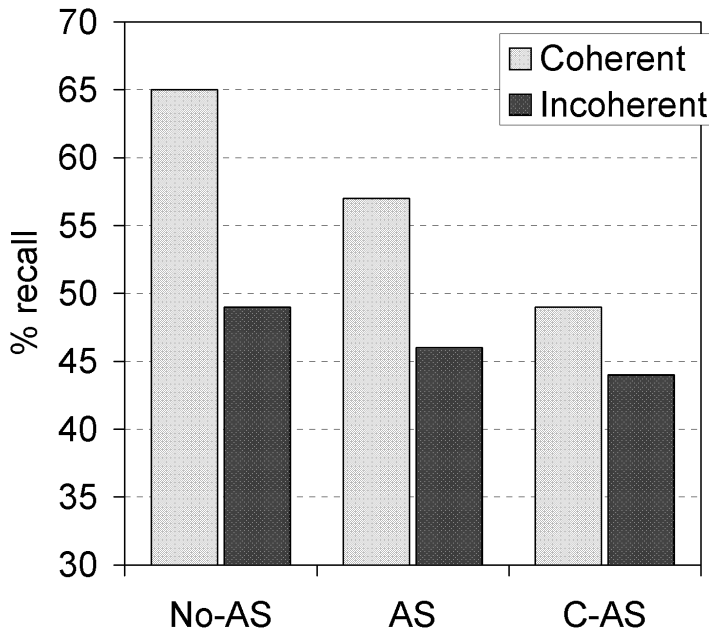
## Results and discussion

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. In other words, it was scored whether the items were present in the written recall, the order in which the items were recalled was not taken into account. Synonyms of the items were considered incorrect (i.e. “speech” instead of “toespraak” [*speech*]). If half of a compound word was produced, half a point was given (i.e., “bloemenstal” [*flower stall*] instead of “bloemenwinkel” [*flower shop*]). Only regarding verb tenses some leniency was used in scoring, for example, using simple past tense was considered correct even if the original form was past perfect (i.e., *organised* versus *had organised*).

A repeated-measures ANOVA was performed with AS condition (No-AS, AS, C-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 Figure 1, the average recall percentages per condition are graphically presented.

Figure 1 shows that the effect of AS condition is much larger for the coherent stories than for the incoherent stories.

*Effects of AS.* Inspection of Figure 1 indicates that the AS conditions influenced performance, but that this task manipulation was far less effective in



**Figure 1.** Mean percentage of recall per AS condition and per coherence condition (no-AS: control condition; AS: articulatory suppression; C-AS: complex articulatory suppression).

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 complex 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 complex 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. C-AS:  $F(1, 29) < 1$ ,  $p > .10$ ,  $\eta^2 = .03$ , although the difference between no-AS and complex 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 complex 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 global story structure present in the coherent conditions to help retaining the story. Under AS the advantage of story structure decreases, especially when complex AS is required, where the difference between the coherent and incoherent condition 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 small, even though there is still some structure present due to the intact sentences. Note, however, that even under the most difficult recall condition recall is not at floor level. Instead, the participants' recall is higher than what is usually considered the capacity of the phonological loop, which is about five to six unrelated words in serial recall (e.g., Baddeley, 2003b).

In the coherent conditions also a difference between standard and complex AS was obtained. 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 with a high degree of rated wordlikeness result in better immediate recall than nonwords without (Gathercole, 1995; Gathercole, Willis, Emslie, & Baddeley, 1991). Articulation of different real words (i.e., in the complex AS condition) rather than repetitive sounds (i.e., in the AS condition) may activate the 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. Another difference between the AS and complex AS conditions is due to the fact that it is more effortful to repeat three different words than is repetition of one and the same sound. The sequence the participant has to repeat is longer and phonologically and articulatory more complex. So, possibly, articulation in the complex AS condition takes up more central resources, which may interfere with recall.

## PART 2: SIMULTANEOUS INTERPRETING

In the second part of this study 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 the first part of this study. Especially in the complex 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.

## Method

*Participants.* The participants of the first part of this study 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 1 min recording taken from a medium-level English listening high school exam in the Netherlands. The experimental SI task-recording was 4.2 min long and consisted of 43 sentences. It concerned a nonscientific text on the science of face perception. The recorded text was spoken by a native speaker of English at a rate of 116 words per minute. In an earlier study participants from the same population reported no problems understanding the text.

*Design and procedure.* After participating in the first part of the study, 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 min.

## Results and discussion

The interpreting performance of the participants was scored using the audio-recordings of their interpretation. A section of the middle of the text was taken to be representative for SI performance. About 2.5 min of audiorecording, or 17 sentences, were rated by two different raters. They rated between zero and three how much of the content the source text sentence was translated into grammatical Dutch (maximum score 51). A score of zero meant that the sentence was not translated at all, a score of 3 meant that almost all of the content of the

TABLE 1  
Correlations ( $r$ ) between SI performance  
and recall in each of the AS conditions,  
and their associated  $p$ -values

	<i>AS condition</i>		
	<i>No-AS</i>	<i>AS</i>	<i>C-AS</i>
$r$	.25	.23	.38
$p$	.09	.11	.02

No-AS: control condition; AS: articulatory suppression; C-AS: complex articulatory suppression.

original text was translated into a grammatically correct Dutch sentence. The interrater reliability was reasonably high:  $p = .92$ . Further analysis was performed on the average rating. The correlation was calculated between SI performance on the one hand, and recall in the no-AS, the AS, and the complex AS (C-AS) conditions on the other hand. Recall scores were taken from Part 1 of this study, 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 1. As expected, recall under AS correlates positively with SI performance. However, only the correlation between SI and complex 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.

## GENERAL DISCUSSION

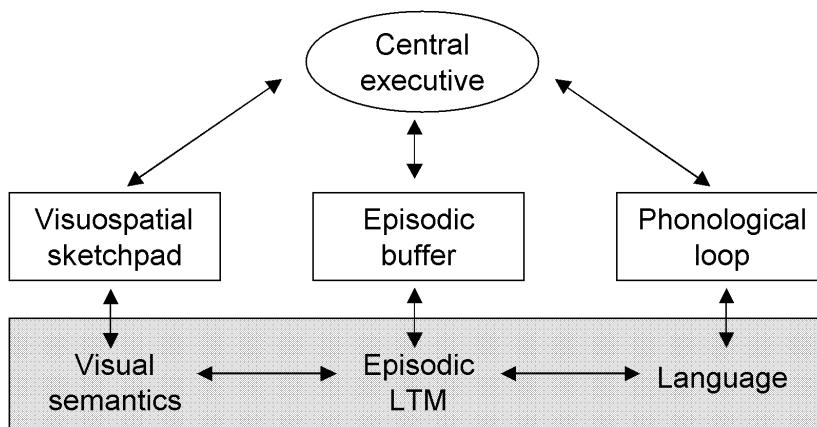
The main conclusion from the first part of the study is that articulatory suppression negatively affects retention of short stories. This finding provides indirect support for the notion that relatively poor recall in interpreting in comparison to listening can be (partly) explained by the interference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

The relevance of recall during AS for interpreting was indicated in the second part of the study by a positive correlation between recall under conditions of complex 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.

A recent revision of the working memory model discussed in the introduction (Baddeley, 2000; see also Baddeley, 2003a, 2003b) 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.

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 global story structure was removed. Do our results therefore indicate that the loop plays a significant role, by activating long-term memory, in using story structure when retaining stories after all? Or do they indicate that the suppression technique influences this new component of the working memory system as



**Figure 2.** The multicomponent working memory model. Shaded areas represent crystallised systems (capable of accumulating long-term knowledge); unshaded areas are fluid systems (attention and storage). LTM = long term memory. Reprinted from *Trends in Cognitive Sciences*, 4, Baddeley, A. D. 'The episodic buffer: A new component of working memory'. p. 421. Copyright (2000) with permission from Elsevier.

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 interfere with the rehearsal process in the loop and not 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 less global story structure to start with, as in the incoherent condition, this structure does assist less in building an episodic structure. In other words, when there is less coherence in the story, it is more difficult to represent information in the episodic buffer since the buffer uses of the meaningful relations in the input. Hence, when the trace of the input is not refreshed this has fewer consequences for recall and therefore recall is likely to be more similar across the three AS conditions in the incoherent condition.

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 reported 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 Part 2 of the study.

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.

Original manuscript received September 2003

Revised manuscript received November 2004

## REFERENCES

- Baddeley, A. (1986). *Working memory*. Oxford, UK: Oxford University Press.
- Baddeley, A. (2000). The episodic buffer: A new component of working memory. *Trends in Cognitive Sciences*, 4, 417–423.
- Baddeley, A. (2003a). Working memory and language: An overview. *Journal of Communication Disorders*, 36, 189–208.
- Baddeley, A. (2003b). Working memory and language: Looking back and looking forward. *Nature Reviews Neuroscience*, 4, 829–839.
- Baddeley, A., & Wilson, B. A. (2002). Prose recall and amnesia: Implications for the structure of working memory. *Neuropsychologia*, 40, 1737–1743.
- Baddeley, A. D., Lewis, V., & Vallar, G. (1984). Exploring the articulatory loop. *Quarterly Journal of Experimental Psychology*, 36A, 233–252.
- Baddeley, A. D., & Logie, R. H. (1999). Working memory: The multiple-component model. In A. Miyake & P. Shah (Eds.), *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 28–61). Cambridge, UK: Cambridge University Press.
- Bajo, M. T., Padilla, F., & Padilla, P. (2000). Comprehension processes in simultaneous interpreting. In A. Chesterman, N. Gallardo San Salvador, & Y. Gambier (Eds.), *Translation in context* (pp. 127–142). Amsterdam: John Benjamins Publishing.
- Barik, H. C. (1973). Simultaneous interpretation: Temporal and quantitative data. *Language and Speech*, 16, 237–270.
- Chernov, G. V. (1994). Message redundancy and message anticipation in simultaneous interpreting. In S. Lambert & B. Moser-Mercer (Eds.), *Bridging the gap: Empirical research in simultaneous interpretation* (pp. 139–153). Amsterdam: John Benjamins Publishing.
- Christoffels, I. K. (2004). *Cognitive studies in simultaneous interpreting*. Unpublished doctoral dissertation, University of Amsterdam (ISBN: 90-9017807-4).
- Christoffels, I. K., & de Groot, A. M. B. (2004). Components of simultaneous interpreting: Comparing interpreting with shadowing and paraphrasing. *Bilingualism: Language and Cognition*, 7, 1–14.
- Christoffels, I. K., & de Groot, A. M. B. (2005). Simultaneous interpreting: A cognitive perspective. In J. F. Kroll & A. M. B. de Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 454–479). New York: Oxford University Press.
- Christoffels, I. K., de Groot, A. M. B., & Waldorp, L. J. (2003). Basic skills in a complex task: A graphical model relating lexical retrieval, working memory, and simultaneous interpreting. *Bilingualism: Language and Cognition*, 6, 201–211.
- Darò, V., & Fabbro, F. (1994). Verbal memory during simultaneous interpretation: Effects of phonological interference. *Applied Linguistics*, 15, 365–381.
- Gathercole, S. E. (1994). Neuropsychology and working memory: A review. *Neuropsychology*, 8, 494–505.
- Gathercole, S. E. (1995). Is nonword repetition a test of phonological memory or long-term knowledge? It all depends on the nonwords. *Memory and Cognition*, 23, 83–94.

- Gathercole, S. E., & Baddeley, A. D. (1993). *Working memory and language*. Hove, UK: Lawrence Erlbaum Associates Ltd.
- Gathercole, S. E., Pickering, S. J., Hall, M., & Peaker, S. M. (2001). Dissociable lexical and phonological influences on serial recognition and serial recall. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, 54A, 1–30.
- Gathercole, S. E., Willis, C., Emslie, H., & Baddeley, A. D. (1991). The influences of number of syllables and wordlikeness on children's repetition of nonwords. *Applied Psycholinguistics*, 12, 349–367.
- Gerver, D. (1974). Simultaneous listening and speaking and the retention of prose. *Quarterly Journal of Experimental Psychology*, 26, 337–341.
- Gerver, D. (1976). Empirical studies of simultaneous interpretation: A review and a model. In R. W. Brislin (Ed.), *Translation: Applications and research* (pp. 165–207). New York: Gardner Press.
- Goldman-Eisler, F. (1972). Segmentation of input in simultaneous translation. *Journal of Psycholinguistic Research*, 1, 127–140.
- Goldman-Eisler, F. (1980). Psychological mechanisms of speech production as studied through the analysis of simultaneous translations. In B. Butterworth (Ed.), *Language production: Vol. 1. Speech and talk* (pp. 143–153). London: Academic Press.
- Isham, W. P. (1994). Memory for sentence form after simultaneous interpretation: Evidence both for and against deverbalization. In S. Lambert & B. Moser-Mercer (Eds.), *Bridging the gap: Empirical research in simultaneous interpretation* (pp. 191–211). Amsterdam: John Benjamins Publishing.
- Isham, W. P. (2000). Phonological interference in interpreters of spoken-languages: An issue of storage or process? In B. Englund Dimitrova & K. Hyltenstam (Eds.), *Language processing and simultaneous interpreting* (pp. 133–149). Amsterdam: John Benjamins Publishing.
- Lambert, S. (1988). Information processing among conference interpreters: A test of the depth-of-processing hypothesis. *Méta*, 33, 377–387.
- Longoni, A. M., Richardson, J. T., & Aiello, A. (1993). Articulatory rehearsal and phonological storage in working memory. *Memory and Cognition*, 21, 11–22.
- Murray, D. J. (1968). Articulation and acoustic confusability in short-term memory. *Journal of Experimental Psychology*, 78, 679–684.
- Padilla, P., Bajo, M. T., Cañas, J. J., & Padilla, F. (1995). Cognitive processes of memory in simultaneous interpretation. In J. Tömmola (Ed.), *Topics in interpreting research* (pp. 61–72). Turku, Finland: University of Turku.
- Thorndyke, P. W. (1977). Cognitive structures in comprehension and memory of narrative discourse. *Cognitive Psychology*, 9, 77–110.
- Treisman, A. M. (1965). The effects of redundancy and familiarity on translating and repeating back a foreign and a native language. *British Journal of Psychology*, 56, 369–379.

## APPENDIX

Example of the experimental stories: Coherent version, incoherent version, and English translation

Coherent version	[De school] [de Windvanger] [bestond] [50] [jaar]. [Om dit] [te vieren] [was [een grote reünie] georganiseerd.] [Honderden] [oud-leerlingen] [zagen [elkaar] weer]. [Na een korte] [toespraak] [van de rector] [ging [iedereen] [de dansvloer] op]. [Gepensioneerden] [van 65] [feestten] [met pubers] [van 18]. [Pas om vier uur] [verliet] [de laatste gast] [het schoolgebouw]. [Het] [was [zo leuk] geweest] dat [de rector] [voorstelde] [elke vijf jaar] [een reünie] [te organiseren]. [Iedereen] [was] [het hier mee eens], [behalve] [de conciërge]. [Hij] [moest] immers [de volgende] [ochtend] [de troep] [opruimen].	The school “de Windvanger” existed for 50 years. A big reunion was organised to celebrate the occasion. Hundreds of former students met each other again. After a short speech of the Dean everybody entered the dance floor (started dancing). Retired people of 65 partied with teenagers of 18. Only at four o’clock the last guests left the school building. The party had been such a big success that the Dean proposed to organise a reunion every 5 years. Everybody agreed except for the caretaker. After all, he was the one having to clean up the mess the next morning.
Incoherent version	Iedereen was het hier mee eens, behalve de conciërge. Honderden oud-leerlingen zagen elkaar weer. Het was zo leuk geweest dat de rector voorstelde elke vijf jaar een reünie te organiseren. Hij moest immers de volgende ochtend de troep opruimen. Na een korte toespraak van de rector ging iedereen de dansvloer op. Om dit te vieren was een grote reünie georganiseerd. De school de Windvanger bestond 50 jaar. Pas om vier uur verliet de laatste gast het schoolgebouw. Gepensioneerden van 65 feestten met pubers van 18.	Everybody agreed except for the caretaker. Hundreds of former students met each other again. The party had been such a big success that the Dean proposed to organise a reunion every 5 years. After all, he was the one having to clean up the mess the next morning. After a short speech of the Dean everybody entered the dance floor (started dancing). The school “de Windvanger” existed for 50 years. A big reunion was organised to celebrate the occasion. Only at four o’clock the last guests left the school building. Retired people of 65 partied with teenagers of 18.

In the Dutch coherent version the items used for scoring are placed in brackets. Note that items had to be reproduced literally and were scored for presence in the written free recall data.