

The study explored the nature of the relation between phonological working memory and sentence comprehension in conduction and agrammatic aphasia. We compared two types of processing required during sentence comprehension: syntactic-semantic and word-form (phonological) reactivation. In both sentence types we increased phonological working memory load by increasing the number of words between a word and the position of its reactivation. We also compared input buffer conduction aphasia (repetition) and output buffer conduction aphasia (reproduction). Finally, we used the same sentences to explore whether the comprehension deficit in agrammatism is related to phonological distance between the antecedent and the gap in relative clauses.

### **Participants**

Eighteen Hebrew-speaking individuals participated in the study: 14 with conduction aphasia and 4 with agrammatism. All participants had pre-morbidly full control of Hebrew, and had at least 12 years of education.

### **Working memory and phonological input-output evaluations**

Recall and recognition span tasks were used to measure phonological WM capacity. Recall tests included word span: phonologically similar/dissimilar as well as long/short words and non-word span. Recognition tests included digit and word spans, listening span and 3 versions of N-back, with two different SOAs.

Output buffer tasks included a full transcription of spontaneous speech, repetition of words and non-words, visual confrontation naming tasks as well as various phonological manipulation tasks such as spoonerism and sound deletions. Input tasks included auditory rhyming judgment tasks and auditory phonological plausibility judgment tasks.

#### *Results of working memory assessment*

- a. Very limited recall spans in all individuals with conduction aphasia.
- b. Two participants had near-normal performance in recognition spans suggesting a selective output buffer deficit. Six participants manifested selective input deficit and six had both input and output disorders.

### **Sentence comprehension experiments**

#### ***Experiment 1: does antecedent-gap distance in relative clauses interact with WM limitation?***

160 Hebrew relative-clauses were included in a binary sentence-picture matching task in which the participant heard a sentence and chose between the matching picture and a reversed-role foil. Number of words between the antecedent and the gap (2,5,7 or 9 words), and relative-clause type (subject vs. object) were manipulated.

#### Examples (translated from Hebrew)

- 1a) 9-word distance object-relative: This is the **NURSE** with the-white gown, the-round eyeglasses and-the-merciful smile that-the-girl dresses\_\_.
- 1b) 2-word distance object-relative: This is the **NURSE** that-the-girl dresses\_\_.

#### *Results*

- a. The individuals with conduction aphasia, whose working-memory was very limited (spans 2-3 words), showed very good comprehension of subject- and object-relative-clause comprehension (89%-96% correct).
- b. None of the conduction aphasics showed any effect of length.

c. The individuals with agrammatism showed a significant effect of sentence type: they failed on object-relatives and performed well on subject relatives, but did not show an effect of distance between the antecedent and the gap.

We conjectured, based on Love and Swinney (1996) and McElree (2000), that antecedent-gap distance had no effect on comprehension because the processing at the gap position involves semantic, rather than phonological, reactivation of the antecedent, and therefore distance that is measured by phonological units and phonological memory limitation does not affect comprehension (see Friedman & Gvion, 2003). This led us to examine comprehension in structures that require phonological reactivation, which might result in impaired comprehension when phonological working memory is limited.

### ***Experiment 2 – does disambiguation distance interact with WM limitation?***

80 Hebrew sentences with ambiguous words that get disambiguated either after 2-3 words or after 7-9 words were included in a plausibility judgment and paraphrasing task (auditory presentation); 100 additional semantically implausible or plausible sentences matched for served as fillers. (see examples 2ab that use the ambiguous word “pen” that means either writing instrument or the place where sheep live). 12 individuals with conduction aphasia participated in this Experiment.

2a) The **PEN** that the student received from his grandma when he graduated was **packed** with wooly sheep.

2b) The **PEN** is always **packed** with wooly sheep.

This type of structure includes temporary lexical ambiguity, that at some point of the sentence gets disambiguated to the less dominant meaning, and thus requires the reactivation of the original phonological word in order to re-access all meanings and allow for reanalysis. Unlike in Experiment 1, in these sentences phonological, rather than semantic reactivation is required, and this type of reactivation might be hampered by phonological overload, and comprehension should be compromised when phonological WM is limited.

### ***Results***

a. All the individuals with conduction aphasia who had a phonological WM limitation (input buffer deficit or “repetition conduction aphasia”) showed a severe deficit in comprehension of long distance disambiguation sentences, rejecting more than half of the sentences as “implausible”. They showed no comprehension problem when the same ambiguity was resolved after 2-3 words.

b. The participants without phonological WM limitation (output buffer deficit-“reproduction conduction aphasia”) did not show any comprehension problem even in this type of sentences.

### ***Experiment 3- does the reactivation of word-form required in rhyming judgment interact with phonological working memory limitation?***

An additional study of the interaction between working memory and phonological reactivation was conducted using a rhyme judgment of structures with short and long distance between two rhyming words. Eighty rhyming and non-rhyming sentences were incorporated in two experimental conditions: short distance of 2-4 words, and longer distance of 7-9 words between the two rhyming words.

### *Results*

The results were similar to the results of Experiment 2, which also required phonological reactivation. All the conduction aphasics that suffer from a input phonological WM limitation showed a deficit in rhyming judgment in the long-, but not in the short-distance condition. The participants without phonological WM limitation (output buffer deficit) did not show an effect of distance.

### *Conclusions*

Our results indicate that in general individuals with conduction aphasia do not suffer from sentence comprehension deficit. It is only a subtype of conduction aphasia and a very special type of sentences that yield a deficit in comprehension in conduction aphasia.

Sentences that require semantic-syntactic reactivation do not pose any problem for the 14 individuals with conduction aphasia who participated in the study. Sentences that required phonological reactivation posed a problem only to the individuals who suffer from limited phonological WM with an input buffer deficit, and only in the presence of phonological overload the exceeded their capacity. The same phonological overload did not have the effect when a syntacto-semantic reanalysis was required.

For the individuals with agrammatism, the deficit in comprehension did not seem to be related to distance and to phonological overload, their performance was not affected by the distance between the antecedent and the gap in either object- or subject-relative sentences. The impairment in the comprehension of object-relative sentences in agrammatism does not stem from the longer distance between the antecedent and the gap in object-relatives.

These results of the current study suggest that phonological working memory is only relevant in a very specific type of sentences. The type of reactivation required by the sentence, as well as the type of memory overload are crucial in determining the effect of phonological WM limitation on sentence comprehension.