# Attention! Behavioral Evidence of Distinct Contributions of Attention and Working Memory to Speech Comprehension

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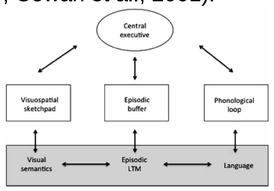
## Background

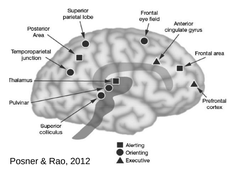
The relationship between working memory and sentence comprehension is well-studied. In general, individuals with reduced working memory capacities demonstrate poorer sentence comprehension abilities, particularly the ability to comprehend complex sentence structures (Just & Carpenter, 1991). However, working memory is not an isolated process and several models highlight a specific relationship between working memory and attention (Baddeley, 2010; Cowan et al., 2001).

For example, the central executive component of Baddeley's working memory model controls and regulates attention between the two subsets of working memory: the phonological loop and the visuospatial sketchpad. Thus, deficits in working memory may actually be attributed to deficits in the attentional control resources that control and regulate the flow of information within working memory. This precursory role of attention within working memory necessitates the need to better understand the role of attention in sentence comprehension.




Selective attention has been the primary focus of much of the literature relating attention abilities to sentence comprehension, and language more broadly. Similar to working memory, individuals with selective attention deficits demonstrate poorer language abilities overall (Peach et al., 2017). However, attention is not a homogenous process and several models of attention exist which divide attention into distinct components beyond selective attention. One model, the Attentional Subsystems Model, outlines three separate components: alerting, orienting, and executive control. Alerting is the initial engagement of attentional resources. Orienting is the selection of specific information from a given stimulus and executive control is the ability to maintain goal-directed behavior by correctly selecting information when irrelevant information conflicts with relevant information (Posner & Petersen, 1990). Each of these subcomponents has been shown to be distinct in neurotypical adults and therefore likely has a unique relationship with sentence comprehension. For example, orienting attention may aid listeners in selecting relevant information from a sentence while executive control may be important for inhibiting potentially competing alternative meanings. Alerting likely plays a more general role in preparing the listener for the onset of a sentence.

Each attention subcomponent is also known to be supported by distinct neural substrates (Petersen & Posner, 2012) with sensory modality also impacting the exact neural resources supporting each attention subtype. For example, a right hemisphere bias is observed for visual attention while auditory attention has been shown to recruit additional regions in the left hemisphere not implicated in visual attention (Coull et al., 1998; Sturm & Willmes, 2001; Thiel & Fink, 2007). This possible hemispheric specialization for visual and auditory attention further necessitates the need to specifically explore the relationship between auditory attention and sentence comprehension abilities.




Posner & Rao, 2012

## Current Study

The present study aims to expand previous work regarding the relationship between cognition and sentence comprehension by investigating the separate contributions of auditory attention and working memory to auditory sentence comprehension abilities in three conditions: (1) with a 15-second time delay between sentence offset and picture presentation to tax working memory, (2) in multi-speaker babble to tax attention, and (3) in silence (i.e., a typical listening control).

**Hypotheses:**

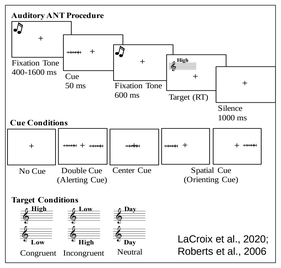
- Significant effects of alerting, orienting, and executive control attention will be observed.
- Neither attention nor working memory will predict auditory sentence comprehension in the control condition.
- Executive control attention will predict auditory sentence comprehension when working memory is taxed.
- Working memory performance will predict auditory sentence comprehension when attention is taxed.

## Participants

39 neurotypical adults who were 18-30 years old, right handed, and native speakers of American English.

## Tasks

### Auditory Attention Task




LaCroix et al., 2020; Roberts et al., 2006

Alerting:
RT difference for no cue – double cue trials
Orienting:
RT difference for center cue – spatial cue trials
Executive Control:
RT difference for incongruent – congruent trials

### Working Memory Task

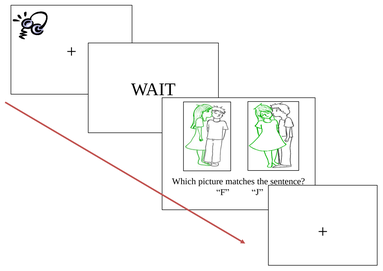
*WAIS-IV* Working Memory Index
(*M*=100, *sd*=+/-15)

Digit Span Subtest
Repeat series of numbers forward, backwards, or in sequence

Arithmetic
Mentally solve math problems of increasing complexity

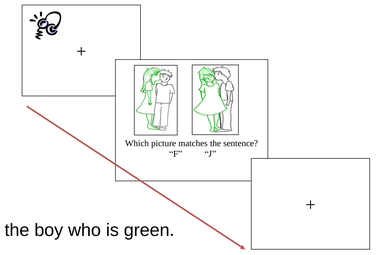
### Sentence Comprehension Tasks:

1. Working Memory Load: 15 second time delay between sentence offset and picture presentation.




2. Attention Load: Target sentence embedded in multi-speaker babble.

3. Control: Target sentence presented in silence.



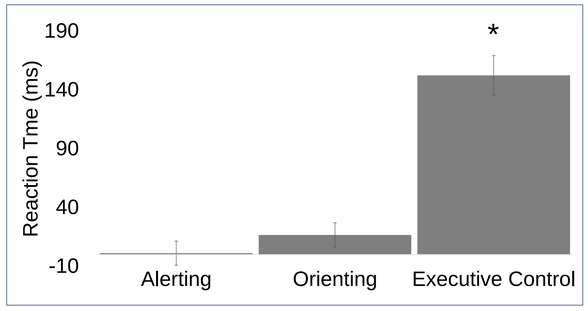

Simple: The girl is kissing the boy who is green.

Complex: The girl who the boy is kissed by is green.

LaCroix et al., 2019

## Results

Auditory ANT identified significant effects of executive control, but not alerting or orienting attention:

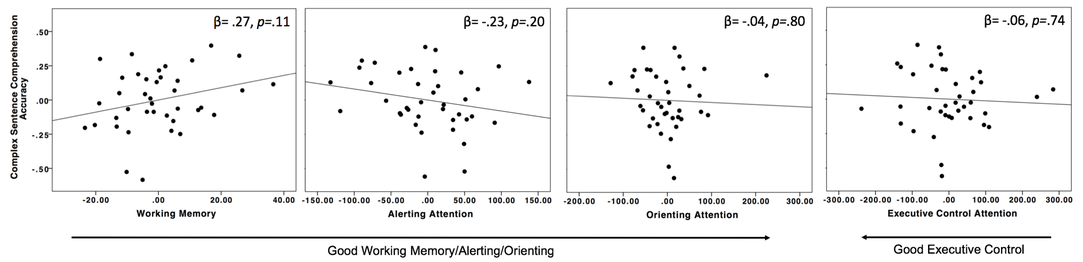



Alerting: $t(38) = .10$, $p=.92$
RT difference for no cue – double cue trials

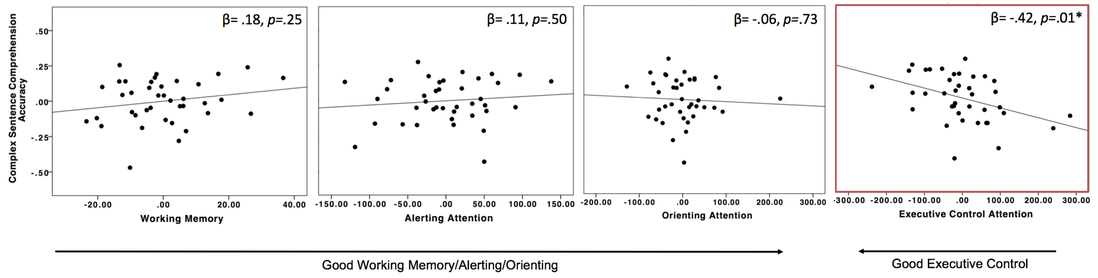
Orienting: $t(38) = 1.6$, $p=.12$
RT difference for center cue – spatial cue trials

Executive Control: $t(38) = 9.05$, $p<.001$
RT difference for incongruent – congruent trials

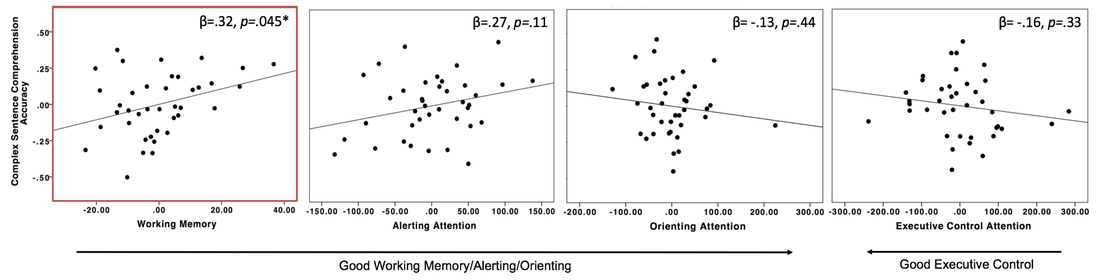
**Control Condition:** Neither attention nor working memory predict auditory sentence comprehension:




**Working Memory Load:** Auditory executive control predicts auditory sentence comprehension:




**Attention Load:** Working memory predicts auditory sentence comprehension:




## Summary

- In neurotypical controls, attention and working memory do not predict auditory sentence comprehension in quiet environments.
- Attention and working memory uniquely contribute to auditory sentence comprehension:
  - Executive control attention supports auditory sentence comprehension when working memory resources are saturated.
  - Working memory supports auditory sentence comprehension when attention resources are taxed.
- Future studies are needed to better quantify the roles of attention (particularly alerting and orienting) in sentence comprehension.

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