Semantic Working Memory Predicts Relative Clause Sentence Comprehension: A Case-series Approach

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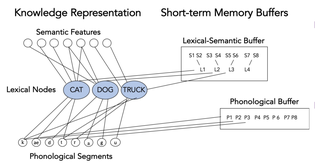
Sentence Comprehension and Working Memory

- Comprehension includes maintaining, processing and integrating linguistic information actively[1].
- By studying people with aphasia who have varying degrees of WM deficits, we can look at the mechanisms relating relative clause sentence comprehension and verbal WM[1,2,5].
- Domain specific model of WM proposes separate buffers to hold different information, specifically semantic and phonological buffers[5].
- Previous research has found a link between semantic WM capacity and sentence comprehension[1,2,3,4,5].
- **Hypothesis**
  - Patients' Semantic WM capacity will have an independent contribution to sentence comprehension and phonological WM capacity will not[1,2,3,4,5].
- **Sentence type (see methods)**
- We used relative clause sentences because they have a working memory component of who did what to whom.
  - Object relative (5) are harder to integrate in comparison to subject relative (4) sentences.
  - Passive sentences (3 & 4) are harder to comprehend than actives (1&2) because of the assumption we make of the first noun of the sentence is usually the agent.
  - Passive embedded (4) has more of a WM demand than passive main clause (3) because you have to process the difficult passive embedded clause while maintaining the subject in WM to integrate with the descriptive clause.



Methods

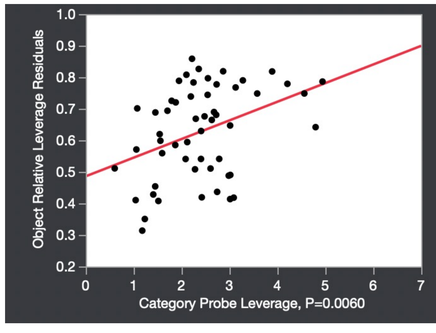
- **Participants:** (N=54) chronic aphasic patients.
  - Mean age = 67 years old
  - Mean years of education = 15 years, Range = [11-22]
- **Multiple regression**
  Regress accuracy for the harder sentence type on semantic and phonological processing measures, semantic and phonological WM measures and accuracy on a baseline sentence type that is easier to comprehend.
- **Semantic processing measures** – Peabody picture vocabulary test, Pyramids and Palm Trees, Single word single picture matching task
- **Phonological processing measures** – Consonant Discrimination, Auditory Lexical Decision, Single word single picture match
- **Phonological WM:**
  - Digit matching task
    - 14365… 13465
    - Same or different?
  - Digit span
    - 18650
    - Repeat numbers in order
- **Semantic WM:**
  - Category probe
    - List: Rose, hurricane, table, hair Probe: Daisy
    - Is the probe word in the same category as any of the words in the original list?
- **Sentence comprehension accuracy measure**
- **Subject relative (1-4)**
- **1.Main active**
  - The boy that had red hair carried the girl.
- **2.Embedded active**
  - The boy that carried the girl had red hair.
- **3.Main passive**
  - The girl that had red hair was carried by the boy.
- **4.Embedded passive**
  - The girl that was carried by the boy had red hair.
- **5.Object relative**
  - The girl that the boy carried had red hair.

Results

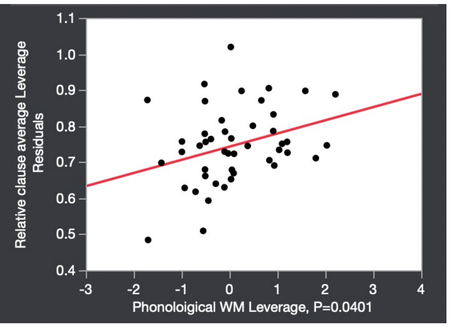
Target sentence regressed on baseline	Beta	t ratio	P value
1) Object relative on active embedded			
phonological WM composite score	0.004	0.19	0.848
category probe	0.059	2.88	0.006*
2) Passive composite (3+4) on active composite (1+2)			
phonological WM composite score	0.007	0.46	0.648
category probe	0.023	1.57	0.122
3) Embedded passive on main clause passive			
phonological WM composite score	0.005	0.27	0.790
category probe	0.034	1.7	0.094
4) Relative clause average on lexical distractors			
phonological WM composite score	0.036	2.12	.040*

*=Significant Correlation

1. Object relative (5) on active embedded (2)



4. Relative clause average on lexical distractors



Discussion

- Category probe (semantic WM) had a significant independent contribution (p=.006) to the comprehension of object relative sentences.
- Our Phonological WM composite score (Phonological WM) had a significant contribution (p=.0401) to the average comprehension of the relative clause sentences when regressed on lexical distractors.
  - It might be that patients that have a damaged semantic WM capacity might use their phonetic WM capacity as a back up.

First case series study of the relationship of WM and sentence comprehension under the domain specific WM model with a statistically sufficient sample size (N=54).

Limitations and Implications

- Should develop an experimental paradigm to test online sentence comprehension of aphasic patients.
- Need to also look at the relationship between language production and the domain specific WM model in healthy individuals.

References

1. Martin, R. C. (1987). Articulatory and phonological Deficits in short term memory and their relation to syntactic processing. *Brain and Language*, *32*(1), 159–192.
2. Martin, R. C., Shelton, J. R., & Yafee, L. S. (1994). Language processing and working memory: Neuropsychological evidence for separate phonological and semantic capacities. . *Journal of Memory and Language*, *33*(1), 83–111.
3. Martin, R. C., & Tan, Y. (2018). Verbal short-term memory capacities and executive function in semantic and syntactic interference resolution during sentence comprehension: Evidence from aphasia. *Neuropsychologia*, *113*, 111–125.
4. Zahn, R., Horne, A., Martin, R.C., (2021). The role of working memory in language comprehension and production: Evidence from neuropsychology. *Cambridge handbook of Working Memory and Language.* In Schwieter, J.W. & Z. Wen (Eds.), Cambridge University Press.
5. Martin, R.C., Rapp, B., Purcell, J. (2020) Domain Specific Working Memory: Perspectives from Cognitive Neuropsychology. In Logie, R., Camos V., & Cowan N (Eds.), . *Working Memory; The state of the science.* (pp.235-281). Oxford University press.

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