

# Verbal fluency and working memory interaction

## INTRODUCTION

Working memory (WM) has been shown to be notably involved in linguistic processing. The most influential model of working memory defines four of its components<sup>1</sup>: the central executive, visuospatial sketchpad, episodic buffer and phonological loop. Psycholinguistic research has been focused on the interaction of linguistic processing with the central executive and visuospatial WM components. Nevertheless, the nature of the **interaction of lexical-semantic retrieval with the WM components** has not become clear.

**Firstly**, research has shown that lexical-semantic retrieval can be automatic, or strategic in which case it uses executive processes<sup>2</sup>. Furthermore, recent research based on verbal fluency suggests that lexical-semantic categories can be categorised as having more automatized semantic links (e.g. *animals*) or less (e.g. *trees*)<sup>3</sup>.

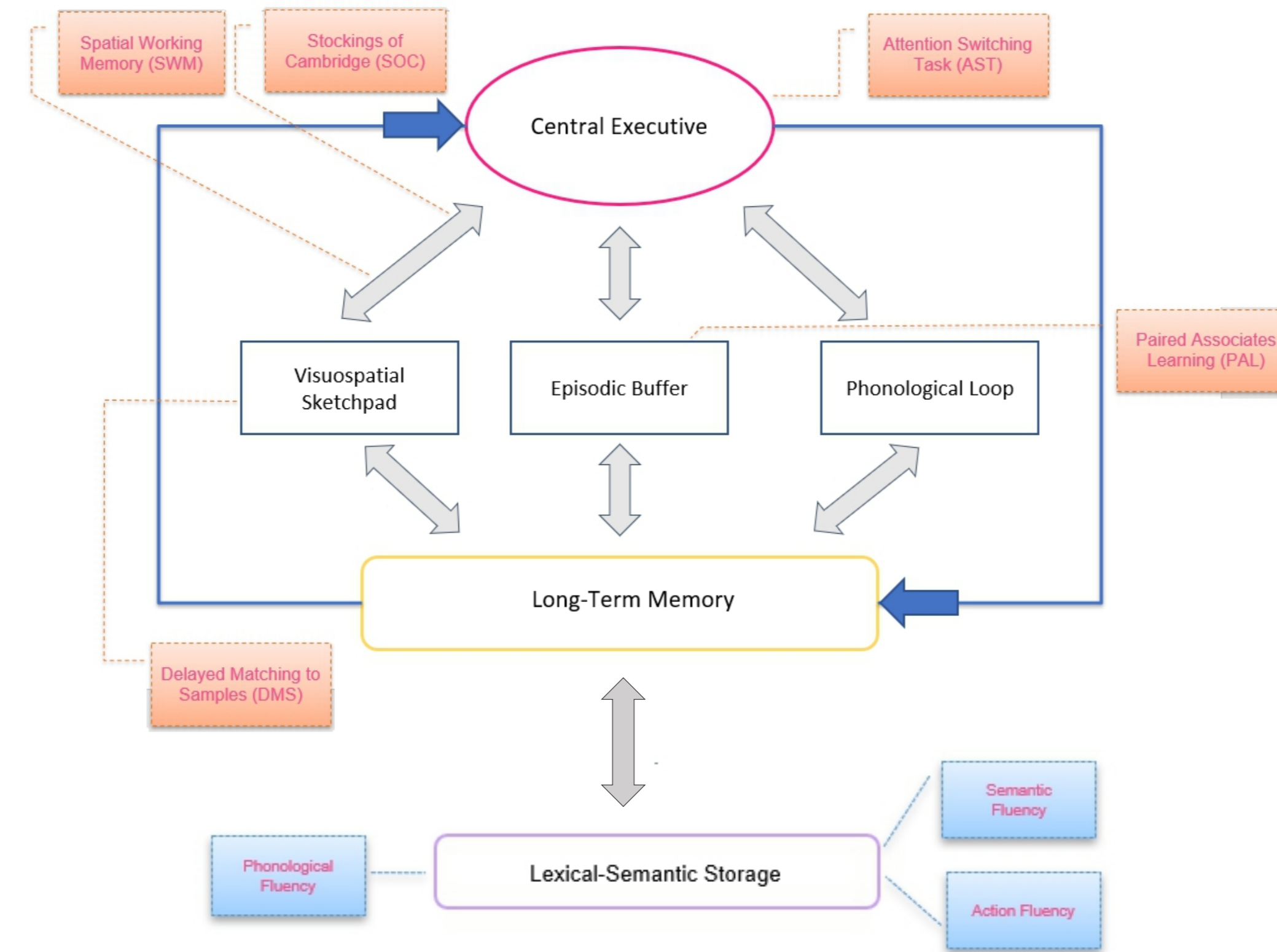
**Secondly**, we relied on models of embodied semantics which predict considerable involvement of visual and spatial information in lexical-semantic processing<sup>4</sup>.

## HYPOTHESES

1. Tree but not animal fluency would be significantly correlated with the central executive.
2. Switching but not clustering would be significantly correlated with the central executive measures.
3. Semantic and action fluency tasks would be significantly correlated with the visuospatial WM component measures.

## METHODOLOGY

The study recruited 20 healthy subjects, ages 20–31 (M=9, F=11). Lexical-semantic retrieval was assessed by verbal fluency (VF). The CANTAB® test battery was administered for assessing WM.

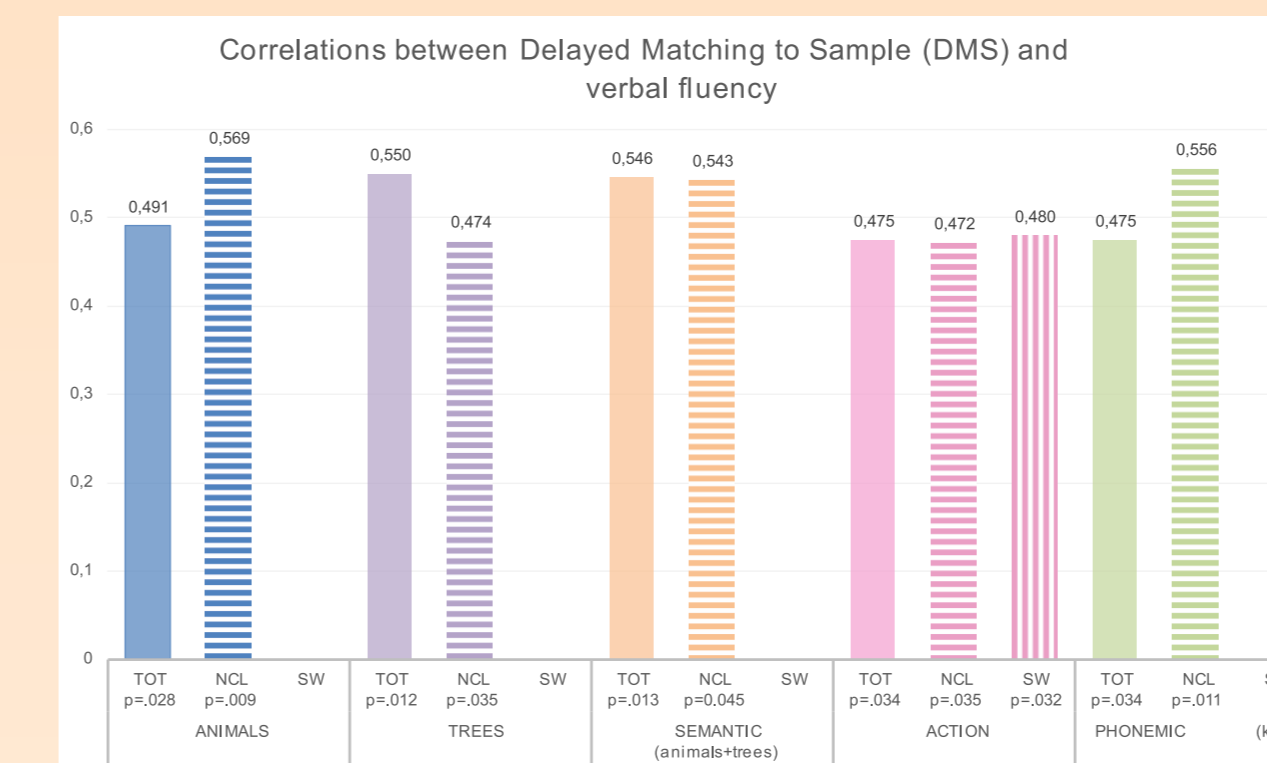


CANTAB® TEST BATTERY (The Cambridge Neuropsychological Test Automated Battery)	VERBAL FLUENCY (60 seconds) Clustering and switching were calculated after Troyer (2000) <sup>5</sup> .
<b>Spatial Working Memory Task (SWM)</b> <ul style="list-style-type: none"> <li>Assesses visuospatial processing and strategy</li> </ul>	<b>Semantic Verbal Fluency</b> <ul style="list-style-type: none"> <li>Animals</li> <li>Trees</li> </ul>
<b>Stockings of Cambridge (SOC)</b> <ul style="list-style-type: none"> <li>Requires spatial planning</li> </ul>	<b>Action Verbal Fluency</b> <ul style="list-style-type: none"> <li>Things one can do in the house</li> </ul>
<b>Attention Switching Task (AST)</b> <ul style="list-style-type: none"> <li>Reflects cognitive flexibility and switching</li> </ul>	<b>Phonological Verbal Fluency</b> <ul style="list-style-type: none"> <li>K</li> <li>M</li> <li>P</li> </ul>
<b>Paired Associates Learning (PAL)</b> <ul style="list-style-type: none"> <li>Assesses visual episodic memory and learning</li> </ul>	
<b>Delayed Matching to Sample (DMS)</b> <ul style="list-style-type: none"> <li>Assesses simultaneous visual matching ability and short-term visual recognition memory</li> </ul>	

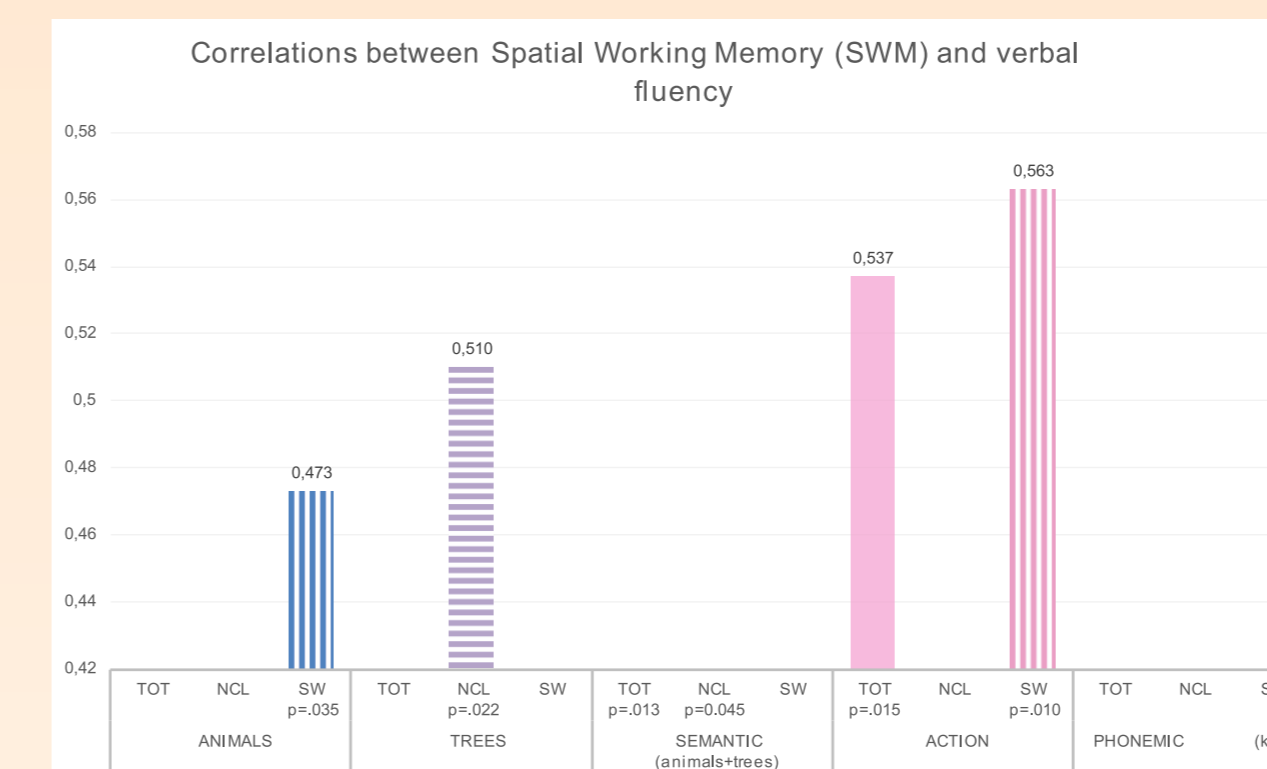
## RESULTS AND DISCUSSION

All correlations are positive in the sense that subjects who were better in the VF also scored better in the neuropsychological tests.

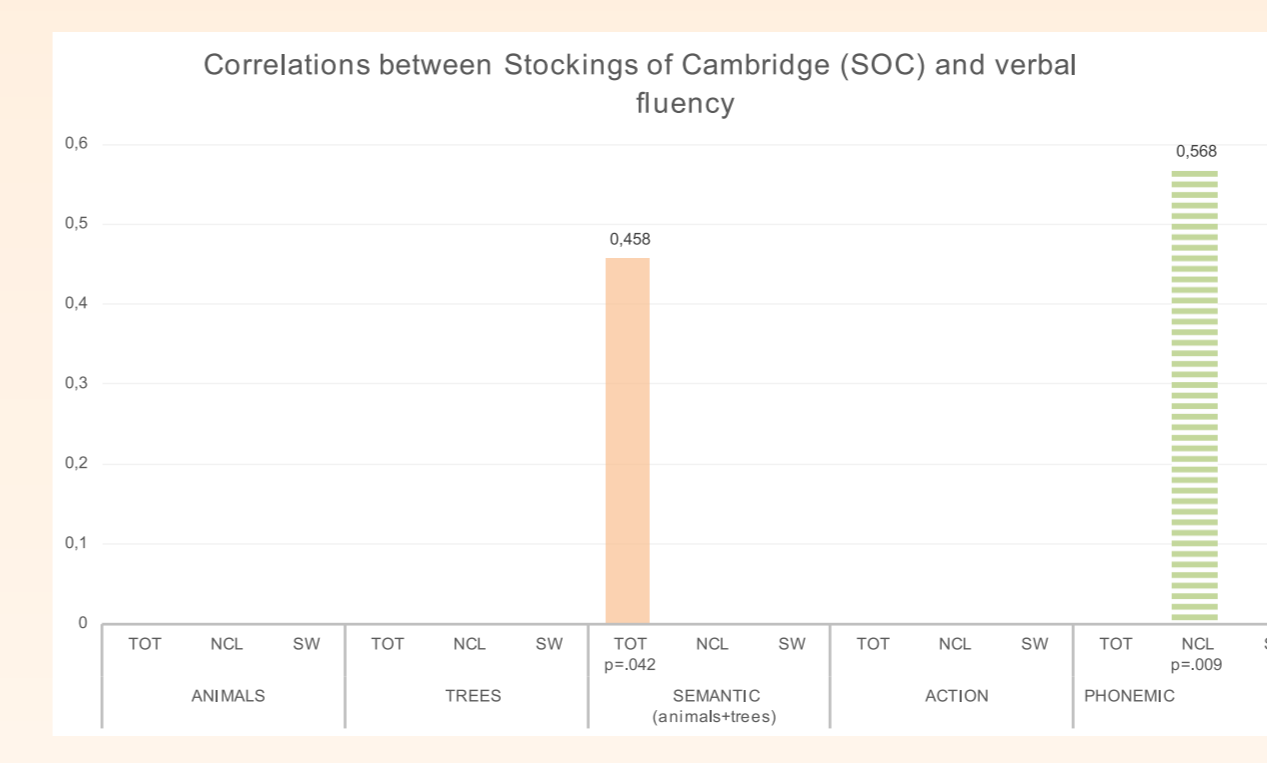
TOT = total number of words NCL = number of clusters SW = switching score



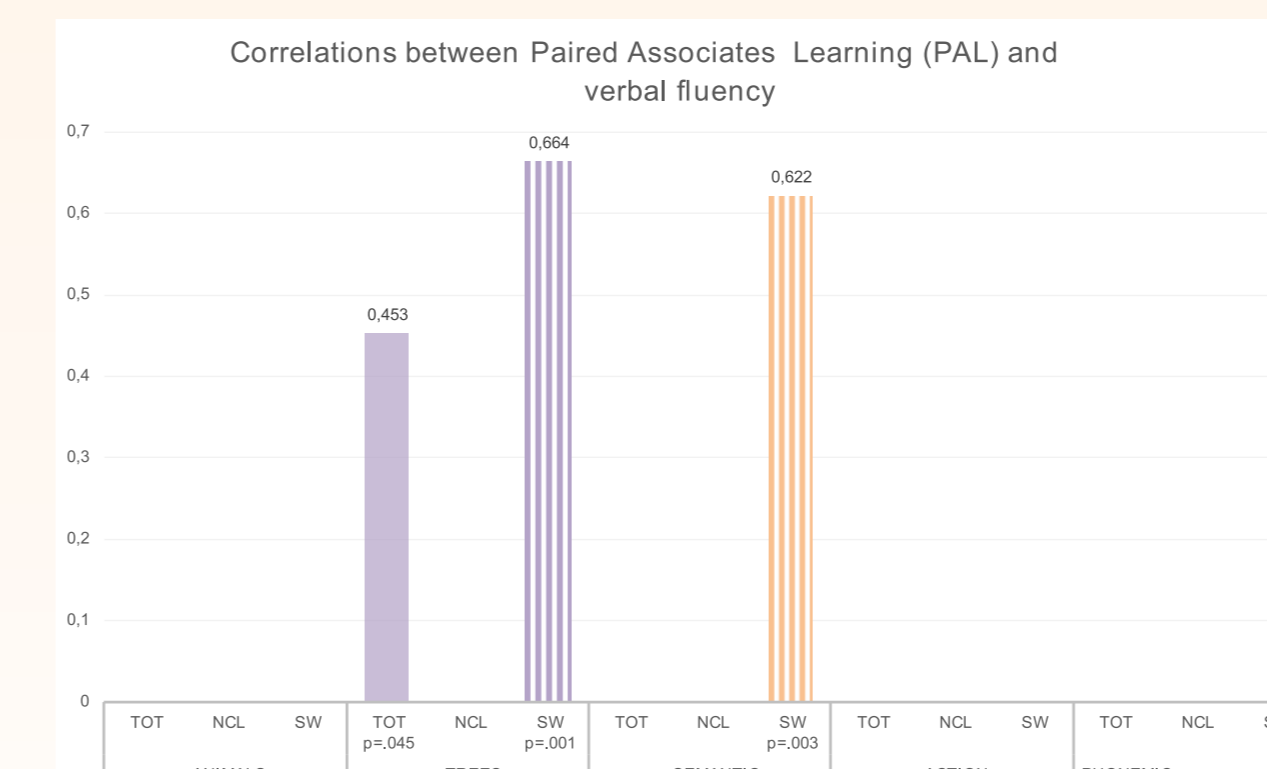
DMS shows significant correlations with TOTs in all VF tasks. It seems to be more involved in clustering than switching. Results suggest that visual information is regularly and possibly automatically implicated in lexical-semantic retrieval.



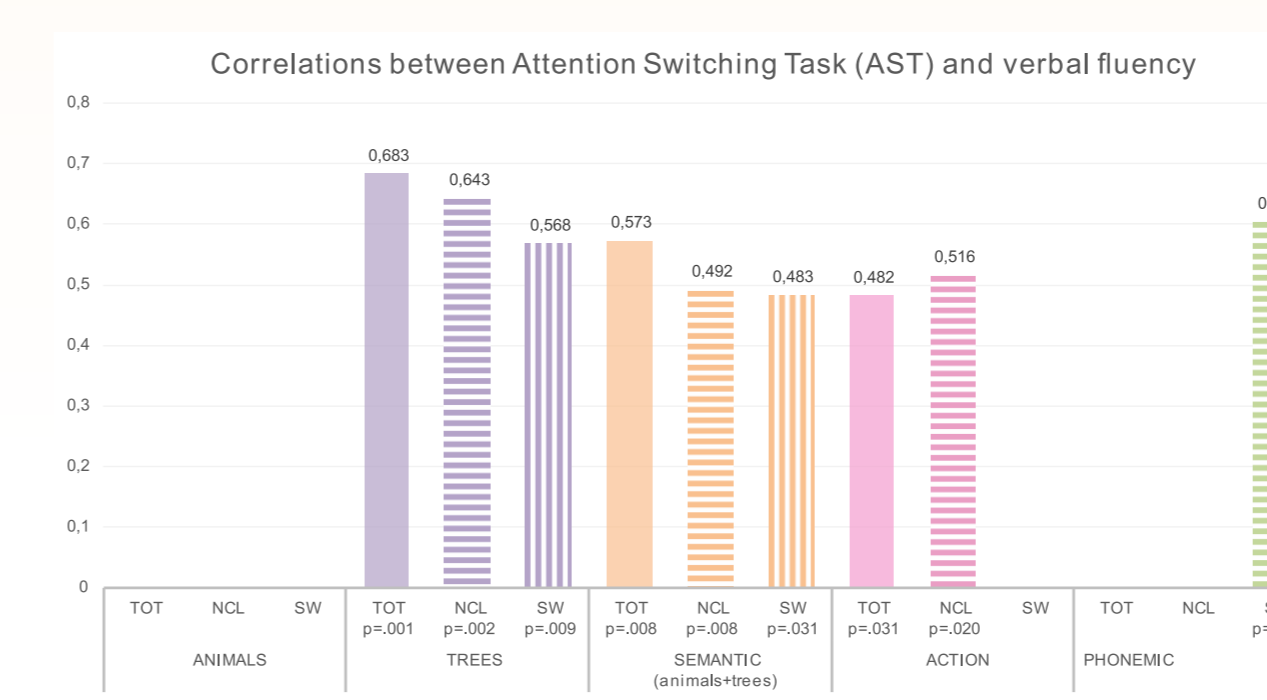
Spatial working memory seems to be mostly involved in action fluency which supports previous research. It is unclear whether significant correlations with semantic fluency indicate retrieval of spatial information or strategy use.



While spatial planning may be limitedly linked to verbal fluency performance, results of SWM and SOC together suggest that lexical-semantic categories never have fully automatized retrieval as indicated by correlations with strategy use and planning.



Tree VF was significantly correlated with PAL measures. Combined results of the study suggest that visual episodic memory retrieval might play a role in non-automatized lexical-semantic retrieval.



Correlations with AST are most visible in the *tree* category of the semantic VF. Results support the hypotheses that the retrieval of lexical-semantic categories with less automatized semantic links, and so a less automatic activation process, is assisted by the central executive, specifically functions involved around attention switching. Correlations were also noted between AST and action VF supporting the hypotheses of executive involvement in action VF<sup>6</sup>.

Because we conducted the phonemic VF after the semantic and action VFs, we calculated the number of words produced in phonemic VF which were already produced in either animal or action VF. Mean percentage of repetitions was 8.67%, median was 7.54%.

## CONCLUSIONS

Our results suggest that:

1. Visual information recall is an essential component of both automatic and less automatic lexical-semantic retrieval processes, showing that modal information is part of the lexical-semantic storage and is not only recalled in a linguistic context.
2. Visual information recall aids clustering strategies in verbal fluency, but is only limitedly related to switching.
3. Retrieval in lexical-semantic categories with less automatized links (e.g. *trees*) is assisted by the central executive, specifically attention switching, and visual episodic memory retrieval. Retrieval in action fluency is assisted by spatial working memory and attention switching.
4. Spatial working memory and specifically spatial planning are limitedly involved in both automatic and less automatic retrieval processes.
5. There are possibly considerable recency effects if phonemic fluency is administered after semantic fluency, or specifically animal fluency.

## REFERENCES

1. Baddeley, A. (2003). "Working memory: looking back and looking forward". *Nature Reviews Neuroscience*, 4, 829–39.
2. Onye, E., Brown, L.A., Riby, L.M. (2017). "Retrieval and monitoring processes during visual working memory: an ERP study of the benefit of visual semantics". *Frontiers in Psychology*, 8, 1050.
3. Gabrić, P., Kužina, I., Vandek, M., Sekulić Sović, M., Mimica, N., Savić, A. (in preparation). "Category fluency in Croatian speakers with first-episode schizophrenia". in: CALS Conference Proceedings, Frankfurt am Main: Peter Lang.
4. Pulvermüller, F. (2013). "How neurons make meaning: brain mechanisms for embodied and abstract-symbolic semantics". *Trends in Cognitive Sciences*, 17(9), 458–70.
5. Troyer, A. K. (2000). "Normative data for clustering and switching on verbal fluency tasks". *Journal of Clinical and Experimental Neuropsychology*, 3, 370–5.
6. Piatt, A. L., Fields, J. A., Paolo, A. M., Troster, A. I. (1999). "Action (verb naming) fluency as an executive function measure: convergent and divergent evidence of validity". *Neuropsychologia*, 37(13), 1499–503.