Individual differences in verbal fluency: The role of linguistic knowledge, processing speed and working memory in healthy young adults

"Name as many animals as you can in one minute." The verbal fluency (VF) task is simple to administer, requires no special equipment, and yet is a valuable diagnostic tool for Parkinson's disease, Alzheimer's disease, and more (e.g., Arias-Trejo et al., 2021). Although the task is simple, it involves not only language skills but also memory, processing speed, and other executive functions. Yet despite the widespread use of the VF task, there is significant debate as to the relative impact of language experience compared to domain-general skills (Aita et al., 2019; Amunts et al., 2020). There are also different ways to score the VF task; we investigate how these two domains of individual differences affect three different scoring methods.

We analyze verbal fluency data (2 **semantic** trials (naming animals/foods) and 2 **phonemic** trials (listing words starting with "m" or "s")) for a sample of 515 young, unimpaired Dutch native speakers. All participants completed an extensive individual differences (ID) battery, allowing us to calculate multi-test factor scores for linguistic knowledge, processing speed and working memory (WM) (Figure 1). We compared three VF scoring methods: **sum scores**, the number of correct words a participant names (the classic performance indicator); **first RT**, the time to the first utterance; and **subsequent RT**, the time when half of the items have been named, indicating when retrieval slows (Shao et al., 2014). These temporal variables represent the time course of retrieval and can be objectively automatically coded from large samples of VF data.

Better scores in both linguistic knowledge and domain-general skills are correlated with better performance in both types and all scoring methods of VF (Figure 2). However, a linear mixed effect model revealed that linguistic knowledge had the largest effect on VF performance in general ($\beta = 0.09$, $p < 0.0001$). Processing speed also played a large role ($\beta = 0.06$, $p = 0.01$).

In terms of VF type, we do not find support for the claim that phonemic VF captures domain-general skill more strongly that semantic VF. Rather, the same IDs affect the two types in a similar way. In terms of scoring method, sum scores were more affected by all IDs than the temporal variables were, particularly by linguistic knowledge (Figures 3 and 4). Finally, sum scores are more affected by both verbal and nonverbal skills than the temporal scores.

In sum, we find that linguistic knowledge is the strongest predictor of VF scores. This means that linguistic knowledge should always be controlled for when investigating the effect of other IDs in VF. There are practical implications for clinical use too; participants who read more and have larger vocabularies should be expected to score higher regardless of other factors. Type of VF task plays little role; phonemic and semantic VF scores capture verbal and nonverbal skills similarly. Finally, the sum score method is most sensitive to both types of skills, suggesting that the traditional scoring method is the best choice for representing both verbal and domain-general skill.

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Amunts, J., Camilleri, J. A., Eickhoff, S. B., Heim, S., & Weis, S. (2020). Executive functions predict verbal fluency scores in healthy participants. *Scientific Reports*, *10*(1), 11141. https://doi.org/10.1038/s41598-020-65525-9

Arias-Trejo, N., Luna-Umanzor, D. I., Angulo-Chavira, A., Ríos-Ponce, A. E., González-González, M. M., Ramírez-Díaz, J. F., Sánchez-Reyes, M., Marín-García, G., & Arias-Carrión, O. (2021). Semantic verbal fluency: Network analysis in Alzheimer's and Parkinson's disease. *Journal of Cognitive Psychology*, *33*(5), 557–567. https://doi.org/10.1080/20445911.2021.1943414

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Fig 1: Schematic representing the test scores that make up the factor scores for the individual difference assessments. Factor scores were calculated using lavaan and consist of multiple test scores to address the task impurity problem.

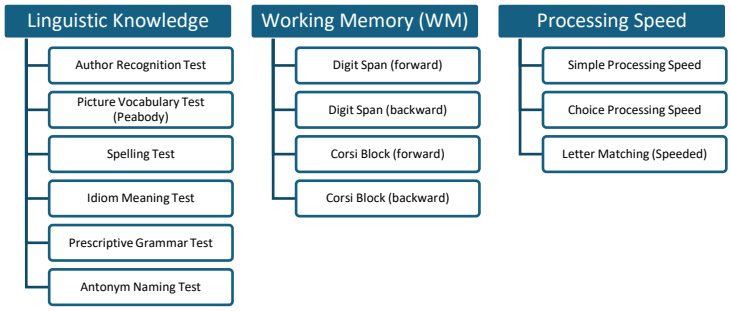

Fig 2: Pearson's correlations between IDs (WM, processing speed and linguistic knowledge) and scoring methods (first RT, subsequent RT and sum scores).

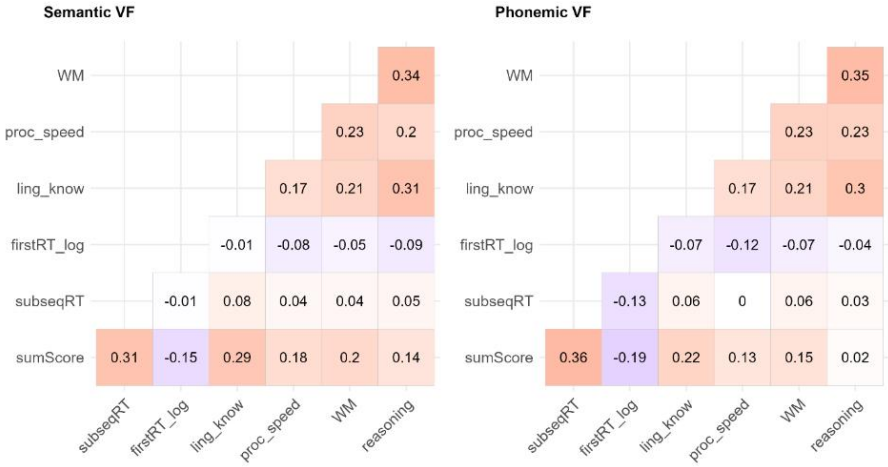

Fig 3: Interaction between linguistic knowledge factor score and verbal fluency score, across the three scoring methods for semantic VF only. (Log) first RTs have been harmonized so that higher scores represent better performance, as with the other scoring methods.

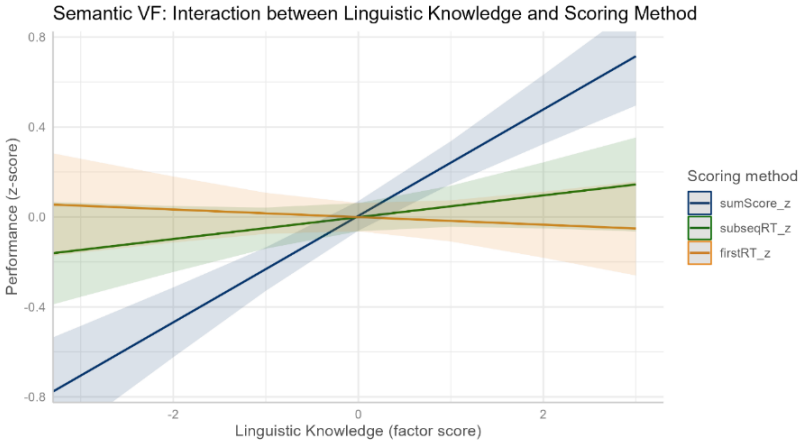

Fig 4: Interaction between processing speed factor score and verbal fluency score, across the three scoring methods for semantic VF only. Phonemic VF was modeled separately.