Analyses of Phonological and Semantic Strategies in Phonemic Fluency for Alzheimer's Disease

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Introduction

- Verbal fluency measures are one of the most frequently used methods that can assess a wide variety of cognitive functions including semantic and phonological memory and executive functions for Alzheimer's disease (AD) (Gomez & White, 2006; Haugrud et al., 2011).
- Previous studies suggested that qualitative analyses of verb fluency measures such as switching and cluster analyses are clinically and empirically important to identify the locus of deficits associated with the fluency measures (McDowd et al., 2011; Rofes et al., 2020).
- Although there are increasing reports on switching and clustering analyses from the semantic fluency measures (Henry et al., 2004; Rofes et al., 2020), there are relatively very few studies on the phonemic fluency analyses for AD.

Purpose of the Study

- The current study analyzed phonemic fluency performance by classifying the phonology and semantic strategies to examine which strategy elicited better performance on the correct number of responses from the phonemic fluency task in AD.

Participants

- Participants with probable AD (n=60) were extracted from the Pittsburgh corpus in the DementiaBank (Becker et al., 1994), which is an open-access database supported by NIH-NIDCD grant R01-DC008524.
- Thirteen participants were excluded from the original corpus based on the following reasons: 1) one participant had the wrong recorded audio file, 2) nine participants generated less than 4 words (which were the minimum requirement for semantic strategy analyses), and 3) three participants were identified as outliers on the outcome measures (>3SD above average; Qiao et al., 2021).
- A total of 47 participants were included in the final analyses. Table 1 provides demographic information of participants.

<Table 1> Demographic information of participants

	Age	Education	MMSE
Mean (SD)	72.28 (±8.60)	11.79 (±2.66)	19.11 (±3.88)
Range	56-88	6-20	10-26

*Values are presented as mean (±SD).
*MMSE = Mini Mental Status Examination (Folstein et al., 1975).

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Task and Analyses

➢ Task

- We analyzed the phonemic fluency task, in which participants were given the instruction to produce words starting with the letter *f* for 60 seconds.

➢ Strategy Analyses

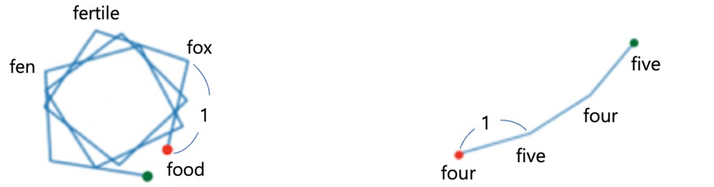
1. Phonological Strategy

- The number of switches and the mean cluster size was calculated for each participant, based on Troyer (2000)'s criteria.
- Criteria of clusters:
  ① the same first two letters (e.g. find-field)
  ② differed only by a vowel sound (e.g. flip-flop)
  ③ homonyms (e.g. fair-fare)
- Switches: transitions between clusters
- Errors and repetitions were included in clusters and switches, but excluded in the correct number of words.

2. Semantic Strategy

- We analyzed the 'word persistence length' as an index.
- The concept of 'persistence length' has been employed for analyzing the DNA or protein structures, which is a widely used basic mechanical property to quantify the bending stiffness of a polymer (Flory, 1969).
- The semantic similarity was employed by spaCy, which is one of the leading open-source in Python libraries for natural language processing.
- Process of analyzing the word persistence length
  ① Semantic vectors were calculated by the cosine angle between the word and the following word, as a word pair for each participant.
  ② The semantic vector from each word-pair explained the degree of changes in the semantic similarity.
  ③ When the word-pair is semantically similar, the cosine angle approaches close to 0°, whereas when it is semantically unsimilar, it approaches close to 180°.
  ④ A graph was drawn for each participant to visualize the degree of changes in the semantic similarity, which explained the word persistence length for each participant.
- We provided examples of word persistence length for low and high cases in Figure 1.

<Figure 1> Low and high cases of the word persistence length



(a) low word persistence value (0.391) (b) high word persistence value (16.322)

* The red dot in represents the starting point, and the green dot represents the end point.

Result

➢ Analyses of Pearson Correlation Coefficients

- We computed Pearson correlation coefficients to determine whether the correct number of words, phonological strategy measures (mean cluster size, number of switches), the semantic strategy measure (word persistence length), and demographic factors (age, education, MMSE scores) are significantly related.
- The correlation results are provided in Table 2.

<Table 2> Results of Pearson correlation coefficients

	Phonological Strategy		Semantic Strategy	Demographic Factors		
	MCS	NoS	WPL	Age	Edu	MMSE
NoCW	.328*	.661**	-.721**	-.091	.012	.350*
MCS	1	-.114	-.344*	.089	.165	.133
NoS	-	1	-.523**	-.067	.142	.266
WPL	-	-	1	-.035	.026	-.230

*NoCW=Number of Correct Words, MCS=Mean Cluster Size, NoS=Number of Switches, WPL=Word Persistence Length, Edu=Education, MMSE=Mini Mental State Examination (Folstein et al., 1975)

➢ Analyses of Stepwise Multiple Regression

- Stepwise multiple regression analysis was conducted to examine the predictors for the number of correct words from the phonemic fluency task.
- We included the mean cluster size, the number of switches, word persistence length, age, education, and MMSE as predictors.
- In the final model for the number of correct words, the number of switches (β=.558, p<.001), word persistence length (β=-13.765, p=.002), and the mean cluster size (β=5.124, p=.013) remained as significant predictors [F(3, 46)=30.550, p<.001, R^2=.681], which explained 68.1% of the variance.

Discussion

- The current study revealed that phonological clusters and switching behaviors are positively related to the performance on the phonemic fluency task (Gomez & White, 2006; McDowd et al., 2011), whereas the semantic strategy, as indexed by the word persistent length, was negatively correlated with the overall performance on the phonemic task.
- The results suggested that individuals with AD who engaged phonemic strategy performed better on the phonemic task, whereas those who relied more on the semantic strategy elicited worse performance.

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