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Clinical use of speech and linguistic features automatically derived from the semantic verbal fluency test

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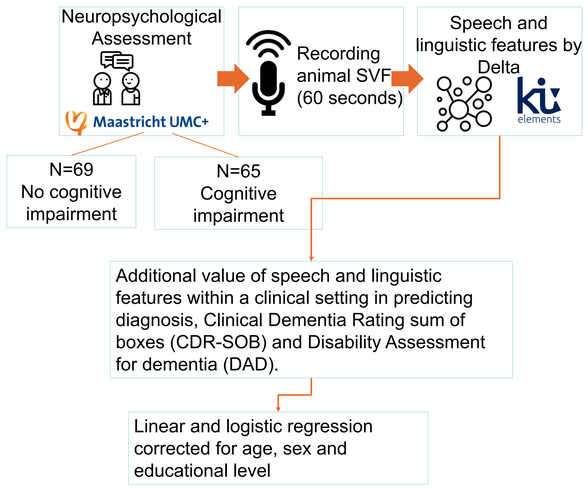
Background

In the course of Alzheimer's disease, speech and language can be affected at an early stage, even before any cognitive deficits are present.[1] The Semantic Verbal Fluency (SVF) task is a cognitive task that allows other diagnostic speech and linguistic features to be retrieved, such as semantic and temporal clustering, switching, the number and length of pauses.[2]

Objectives

- In the present study, we investigated the (additional) value of automatically derived speech and linguistic features of the SVF task in the early diagnosis of cognitive impairments.
- Additionally, we examined the relationship between these speech and linguistic features of the SVF and disease severity and functioning in daily living.

Methods



Results

134 individuals were included, consisting of 69 people without cognitive impairment (Subjective Cognitive Impairment) and 65 people with cognitive impairment (Mild Cognitive Impairment and dementia). Compared to people without cognitive impairment, those with cognitive impairment were significantly older, and had a lower score on the MMSE, CDR SOB and DAD (Table 1).

Table 2 shows the results of logistic regression analyses on the association between speech and linguistic features and **diagnostic classification**. Lower *temporal mean cluster size* was significantly associated with cognitive impairment.
Speech and linguistic features had an added value (55.1% Nagelkerke R^2), compared to the clinically used total word count (R^2=0.443). The most important individual linguistic feature which significantly added value to the total word count was *word frequency range* (OR 0.41, 95%CI 0.18-0.93).

The speech and linguistic features *word frequency range* (β = 0.39; *t*(112)= 2.48 *p* =.015) and *temporal mean switch transition* (β = .07; *t*(112)= 2.97; *p* <.01) were significantly associated with **CDR SOB.**
Adding speech and linguistic features to the model with the traditionally used word count resulted in an increase (11.2%) of explained variance (R^2=37.9%, *p*=0.057). The most important individual linguistic features which significantly added value to the total word count were *word frequency range* (β = 0.34; *t*(111)= 2.07; *p* =.041) and *temporal mean switch transition* (β = .07; *t*(111)= 2.88; *p* <.01).

The speech and linguistic features *word frequency range* (β = -4.78; *t*(104)= -2.96; *p* <.01) and *semantic mean cluster size* (β = -2.20; *t*(104)= -2.23 ; *p* = 0.028) were significantly associated with the **DAD**.
Adding speech and linguistic features to the model with the traditionally used word count resulted in an increase (13.1%) of explained variance (R^2=0.315, *p*=0.066) The most important individual linguistic features which significantly added value to the total word count were *word frequency range* (β = -3.84; *t*(103)= -2.31; *p* =0.023) and *semantic mean cluster size* (β = -2.97; *t*(103)= -2.83; *p* <.01).

Table 1. Sample characteristics.

	No cognitive impairment (N=69)	Cognitive impairment (N=65)	p-value
Age - mean(SD)	62.20 (10.71)	71.83 (9.65)	<0.001[1]
Male %	45 (65.2%)	39 (60.0%)	0.533[2]
Education (low/mid/high %)	28/36/36	40/29/31	0.310[2]
CDR sum of boxes - mean (SD)	0.77 (0.86)	1.95 (1.55)	<0.001[1]
DAD-percentage – mean (SD)	94.60 (7.96)	84.10 (14.72)	<0.001[1]
MMSE – mean (SD)	28.71 (1.23)	26.22 (2.52)	<0.001[1]

[1]Independent t-test
[2]Chi-square test

Speech and linguistic features

Temporal mean cluster size = Words that are named together in time are a cluster. The average size of the clusters based on the time in which the participant names the animals.
Word frequency range = The difference between the most and the least frequent word mentioned by a participant.
Temporal mean switch transition = The average time it takes to switch between clusters.
Semantic mean cluster size = Words that are named together in a semantic cluster. The average size of the clusters based on the time in which the participant names the animals.

Table 2. Binary logistic regression on the association between speech and linguistic features and diagnostic classification.

	Odds ratio	SE	95% CI Lower Limit	Upper Limit	P-value
Model 1					
Age	1.09	0.03	1.04	1.15	0.001
Education low	0.64	0.59	0.20	2.03	0.450
Education high	0.58	0.61	0.18	1.90	0.367
Sex	0.60	0.49	0.23	1.57	0.300
Model 2					
Mean word frequency	1.19	0.93	0.19	7.35	0.853
Word frequency range	0.58	0.36	0.29	1.19	0.138
Temporal mean cluster size	0.32	0.57	0.11	0.98	0.047
Temporal number of switches	0.83	0.31	0.45	1.52	0.540
Temporal mean time in cluster	1.08	0.19	0.74	1.58	0.702
Temporal mean transition time intracluster	1.08	0.27	0.64	1.82	0.785
Temporal mean time switch transition	1.11	0.10	0.92	1.34	0.282
Semantic Mean cluster size	4.84	1.80	0.14	163.27	0.380
Semantic Number of switches	1.01	0.13	0.78	1.29	0.963
Semantic Intercluster similarity	0.95	1.31	0.07	12.25	0.967
Sem. Intracluster similarity	3.65	2.68	0.02	691.25	0.629

Conclusions

- Automatically derived speech and linguistic features are associated with diagnostic classification, impairment in daily living and disease severity.
- Automatically derived speech and linguistic features of the SVF have an additional value in the early diagnostics of cognitive impairments.
- Word frequency range specifically seems to have an additional value in predicting diagnosis, disease severity and impairment in daily living.

References

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