# Animacy distinctions and semantic dementia

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https://doi.org/10.36505/ExLing-2019/10/0031/000393

## Abstract

We explored relationships between performance in "living" and "non-living" animacy distinctions and brain metabolism in patients with a semantic variant of a primary progressive aphasia (Sv-PPA) as well as healthy volunteers. Outcomes did not convincingly support differences in the processing of living' vs 'non-living' items in Sv-PPA patients, and point out at complex potentially interesting anatomical specialization in the processing of these two types of categories, which should be further pursued in a larger cohort.

Key words: animacy distinction, impairment, semantic category, hypometabolism, temporal lobes, correlation.

## Introduction

The difficulty in word-finding is the most evocative of language disorder. This impairment is characteristic of sv-PPA, a progressive neurodegenerative disorder affecting semantic capacities. However, not all semantic concepts seem to be identically affected. Prior research has shown that the conceptual category of 'living' (divided into 'animate' and 'non-animate') is particularly affected, independently from other semantic categories. Nonetheless, this finding has not always been replicated and remains controversial. Sv-PPA patients show clear signs of atrophy and hypometabolism in anterior temporal lobes (ATLs) with a left side predominance. ATL plays a crucial role in semantics. The ATLs encompass a region composed of cortical areas, which differ significantly with regards to their cytoarchitectural organization and connectivity patterns (Kondo et al. 2003). Here, we aimed to explore: dissociations between 'living' vs 'non-living' items processing in Sv-PPA, using a correlational approach between behavioral outcomes in semantic tasks and regional metabolic maps in areas of temporal lobes.

## Materials and methods

Fourteen Sv-PPA patients and five healthy subjects (HS) were recruited. All measurements were obtained as part of an ongoing clinical trial sponsored by AP-HP (PHRC National 'Stim-SD'). Analyses focused on three computer-based language tasks: 1) a *verbal semantic association* task (AS verbal / 26 trials); 2)

a *visual semantic association* task (AS visual / 26 trials); 3) a *categorical decision* task (CD task / 40 trials). The same day, participants underwent a PET-MRI study. Accuracy and reaction times (RT) of correct responses for 'living' and 'non-living' items were separately recorded. As well as Inverse Efficiency (IE) measure, calculated by dividing the RT by 1–proportion of Errors (PE) for each category in order to factor jointly *speed* and *accuracy* of correct responses during task execution. PET analyses employed the AAL atlas and focused on the six regions of interest: bilateral Middle Temporal Pole, Superior Temporal Pole and Parahippocampal Gyrus. Non-parametric Wilcoxon test was used to estimate the statistical significance between semantic categories, and Spearman or Pearson for correlation coefficients between metabolic levels and categorization performance.

## Results

Accuracy differences between the two item categories reached significant differences ($p=0.03787$) only for the semantic categorization (CD) task, showing higher accuracy for 'non-living' compared with 'living' items. However, the RT for correct responses was faster for 'living' than for 'non-living' category ($p = 0.004028$). A trend ($p>0.05$) for IE suggests higher values for 'living' vs 'non-living' items. For HS, no statistical significance was found for accuracy, despite a benefit of correct responses for "non- living" category observed.

Most significant correlations in Sv-PPA patients concerned the processing of 'non-living' category (Accuracy and IE) and FDG metabolism in right temporal pole subregions. The correlations identified category-specific temporal lobe regions i) in the superior temporal pole for 'living' items, ii) and in the right middle temporal pole for 'nonliving' items. The right superior temporal pole metabolism scaled with the performance of both 'non-living' but also 'living' items. Additionally, bilateral parahippocampal cortex showed exquisite category- and task-specific dependency for 'living' items only when tested with the AS visual semantic task. Readers should bear in mind that none of the correlations presented in this section survived at the Bonferroni correction for multiple comparisons (corrected thresholds at $p<0.008$). Hence at the current stage, the above-reported correlations should be considered significant using uncorrected statistical approaches, hence be taken very cautiously.

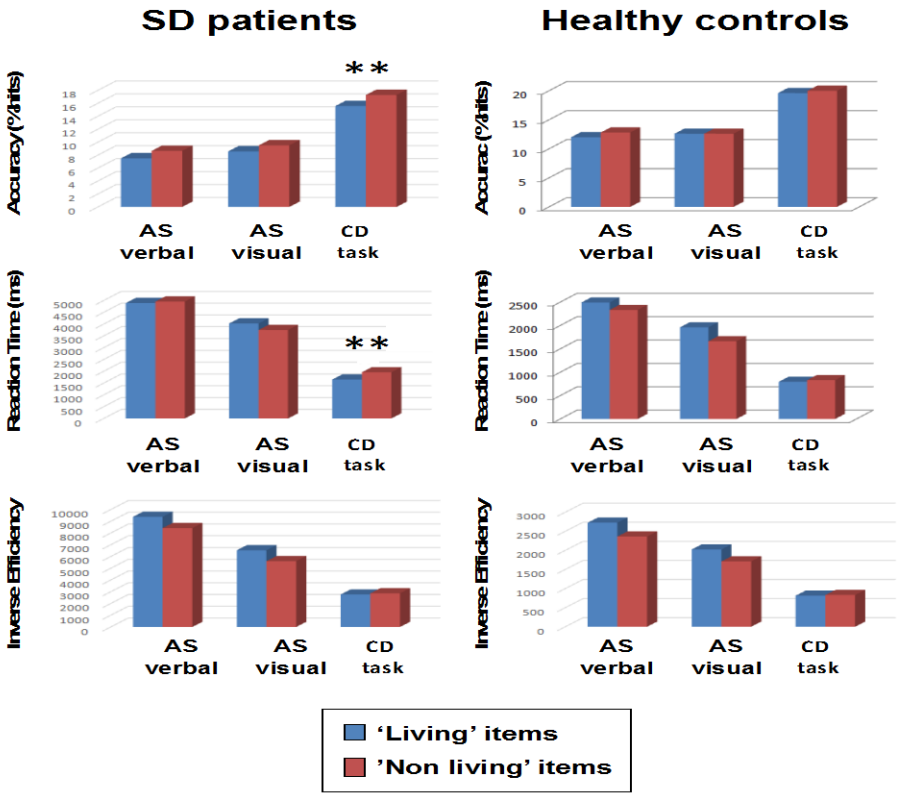


Figure 1 Histograms presenting behavioral outcomes (from top to bottom rows: Accuracy (% correct), Reaction Time for correct responses (in milliseconds, ms) and Inverse Efficiency for 'living' and 'non-living' items for the 3 tasks (AS verbal: AS visual: and CD). Significant differences ($p<0.05$) are indicated by **.

## Discussion and conclusions

Our preliminary results failed to find robust evidence a differential processing of 'living' compared with 'non-living' category items in Sv-PPA patients. Correlational analysis between performances and regional FDG metabolism in temporal lobe yielded insightful but complex and overall statistically fragile outcomes. However, higher deficits for the categorization of "living" have been shown. The IE measurement yielded a cancellation of such significant differences, raising doubts on such category-specific dissociation in Sv-PPA reported for accuracy measures in the CD task. This outcome supports the view that a significant and reliable benefit for "non-living" reported elsewhere for Sv-PPA patients may fall under the 'exception' rather than be the rule (Lambon Ralph et al., 2007). Our results allow to nuance the classical notion of the ATL as a trans-modal convergence 'hub' (Roger et al., 2017) and suggest

that the two semantic categories could eventually be processed by different ATL sub-regions. The right superior temporal pole would act as a non-specific ATL region. The correlation with the parahippocampal region tied to performance in the AS visual task, which could be explained by the role of this area in contextual association retrieval (Baumann & Mattingley 2016). Moreover, assessing access to specific semantic categories with visual material only (words or pictures) in Sv-PPA patients affected by anomia and/or prosopagnosia might be prone to uncontrolled biases and potentially reflect difficulties in item identifying. Incorrect response does not unequivocally inform on a breakdown accessing its concept, but could reflect difficulties in identifying its structural attributes.

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