Associative transitions in language processing

Introduction: Understanding the neural mechanisms underlying language processing is challenging. So far, most studies aiming in this direction measure responses to semantic/syntactic violations (e.g., [1]) and may thus not be adequate to describe language processing during comprehension in the absence of these constraints. Thus, we have been developing novel tasks, which include familiar stimuli and do not introduce any kind of violations.

Here, we have designed a new paradigm in order to explore the associative neuronal mechanisms that may underlie language processing, which have previously been characterized with models of latching dynamics ([2],[3],[4]). In particular, we attempt contrasting the brain signatures of different types of transitions between words. These have been hypothesized to reflect transitions between discrete brain states ([3],[4]), but have thus far not been addressed in an everyday-like experimental setup.

We have conducted two experiments, a behavioural one and an ERP experiment.

Design: Participants are presented with 12 rounds of a computer game. Each game includes 28 Italian words (displayed in a 7x4 grid), which latch onto one another through one of 7 different types of transition: letter-addition (e.g., auto – avuto), -omission (e.g., scorretti – sorretti), -change (e.g., gira – gara), anagram (e.g., cromate – mercato), antonym (e.g., selvatico – domestico), synonym (e.g., maniero – castello), and semantic relation (e.g., galline – uova). The goal of the game is to find the (only) correct sequence, and move quickly to the next round. The game is based on a similar game, called "Il Bersaglio", which has been known for many decades to readers of the venerable Italian journal of crosswords puzzles and riddles "La Settimana Enigmistica". A computer version has been produced by Franco Ceccherini, who has kindly agreed to share it with us. Ours is a modified version of his.

Results – Behavioural experiment:

Prior to the EEG experiment, we conducted a behavioural, reaction time (RT) experiment in order to test the validity of the task. Figure 1 shows the considerable variability in the mean RT among seven different types of transitions, also among semantic and word-form subtypes, and relative to the variability within each subtype. There is a factor of 2 between the mean time required for the fastest (letter-omission, ca. 4s) and for the slowest (anagram, ca. 8s) type of latching.

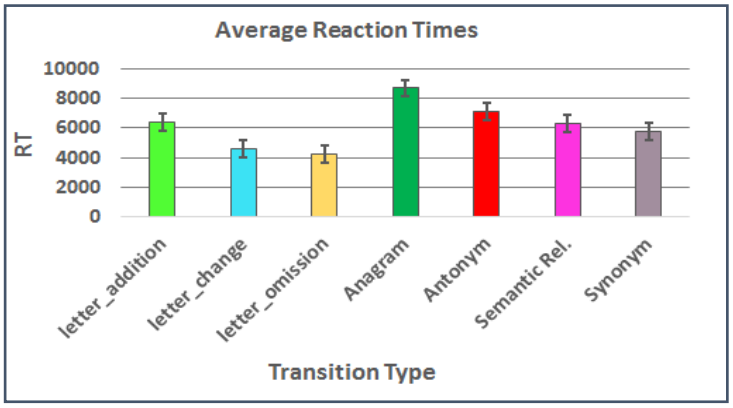

Figure 1

We ran a paired samples test with the two different transition classes, semantic (i.e. antonym, semantic relation and synonym) and word-form (i.e. letter-addition, -change, -omission); anagram was omitted since it presents characteristics of both classes. Results confirm that the reaction times are significantly faster in the word-form transition class ($t(18) = -2.957$, $p = .008$).

Results - ERP experiment: Results of the pilot ERP study indicate different ERP signatures for the two main classes of transitions – semantic and word-form one. Figure 3 presents the cluster analysis (see figure 2 for cluster in consideration) in the period from 1400ms before and 400ms after the word selection (0ms).

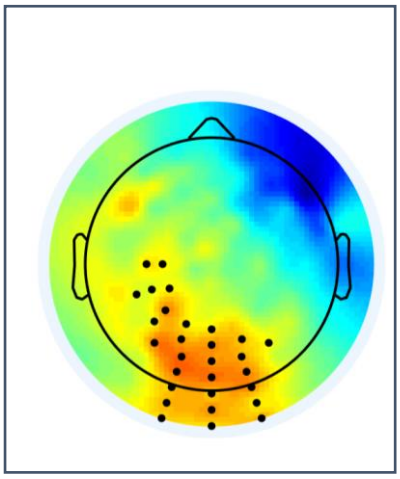

Figure 2

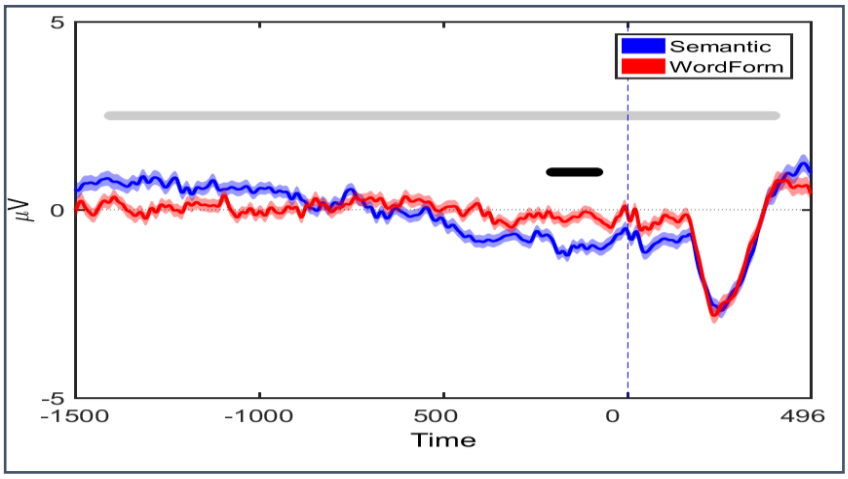

Figure 3

Discussion: In this study, we present a novel paradigm to disentangle distinct associative mechanisms that contribute to language processing. The new paradigm avoids the use of syntactic or semantic violations, but rather focuses on real-word stimuli within a highly engaging game environment. The results of the behavioural experiment suggest that there is a difference in the processing of different types of transitions, which can be observed at least in the different reaction times. Furthermore, the first ERP data visualisation suggests differences in the EEG signatures of specific transition types, and is thus promising for our goal of relating distinct brain signatures to different associative mechanisms underlying semantic and word-form processing.

References:

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