

Implicit-statistical learning in aphasia and its relation to lesion location

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Introduction: Implicit-statistical learning (ISL) research investigates whether domain-general mechanisms are recruited in the linguistic processes that require manipulation of patterned regularities (Misyak & Christiansen, 2012). Neuroimaging research yielded robust evidence to suggest that ISL mechanisms activate anatomical regions which overlap with those activated by syntactic processing (Bapi et al., 2005). Aphasia is a language disorder caused by brain damage in the left fronto-temporal-parietal network (Caplan, 2015). Research shows that people with aphasia (PWA) with frontal lobe lesions (f-PWA) manifest convergent deficits in syntax and ISL mechanisms however direct empirical evidence is limited (e.g. Zimmerer et al., 2014). So far, ISL mechanisms in PWA with posterior lesions (i.e. temporal or parietal lobes) (p-PWA) have not been systematically investigated. We examined two complementary hypotheses: 1) *the anatomical hypothesis*, that f-PWA display more severely impaired ISL abilities than p-PWA and 2) *the behavioural hypothesis*, that the magnitude of impairment in ISL mechanisms correlates to syntactic deficits in aphasia.

Methods: We tested 13 PWA, 5 f-PWA and 8 p-PWA, and 11 healthy controls on a non-linguistic visual statistical learning (VSL) task (van Witteloostuijn et al., 2019). The VSL task consists of two phases: the familiarization is an online RT-based task during which the participant is exposed to the visual stimuli (i.e. 12 aliens). Unknown to the participant, the aliens are repeatedly arranged in the same groups of three, i.e. triplets (see Figure 1 for illustration). The aim of the familiarization phase is to measure the online learning effect. This is followed by the post-familiarization phase which consists of two tasks that measure the presence and the magnitude of the offline learning effect (see Figure 2 for example of stimuli). Additionally, PWA completed the Russian Aphasia Test (RAT) and two measures were derived, syntactic competence (combined score of tasks: sentence comprehension & sentence production) and lexical competence (combined score of tasks: word comprehension, naming). Linear mixed-effect models were built to evaluate group differences on online and offline VSL tasks. The relationship between VSL task performance and linguistic deficits in aphasia were assessed through correlational statistics.

Results: There is no evidence that p-PWA display stronger learning effect than f-PWA on online and offline VSL tasks. Instead, healthy subjects performed significantly better than all PWA combined on the online task (RT's measure, $\Delta z = 0.104$, 95% CI [0.017...0.192], $t = 2.366$, $p = 0.018$) and the offline task (accuracy measure, log odds = +3.217, CI 95% = [1.296 ... 8.775], $p = 0.013$). Lastly, the accuracy on the VSL task and syntactic competence weakly correlated in PWA, independently of lesion location ($r = 0.156$, CI 98.75% = [0.015 ... 0.290], $p = 0.005$). The accuracy on the VSL task did not correlate to lexical competence in PWA.

Conclusion: Our first key finding regarding the hypothesized anatomical localization of ISL mechanisms remained unsupported, and we demonstrate that patients whose frontal regions were spared, but whose posterior regions were in fact lesioned, manifest impaired ISL mechanisms. Our second key finding is that the magnitude of the learning effect on the VSL task correlates to syntactic, but not to lexical competences of PWA. This suggests that a) domain-general ISL mechanisms at least partially overlap with mechanisms recruited in language processing and b) ISL mechanisms are recruited in the linguistic modules that require exploitation and manipulation of patterned regularities, such as syntax.

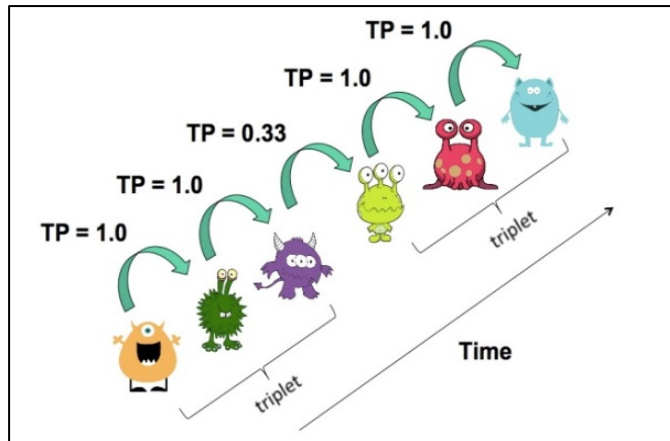


Figure 1. Transitional probabilities (TP) of aliens within triplets (van Witteloostuijn et al., 2019)

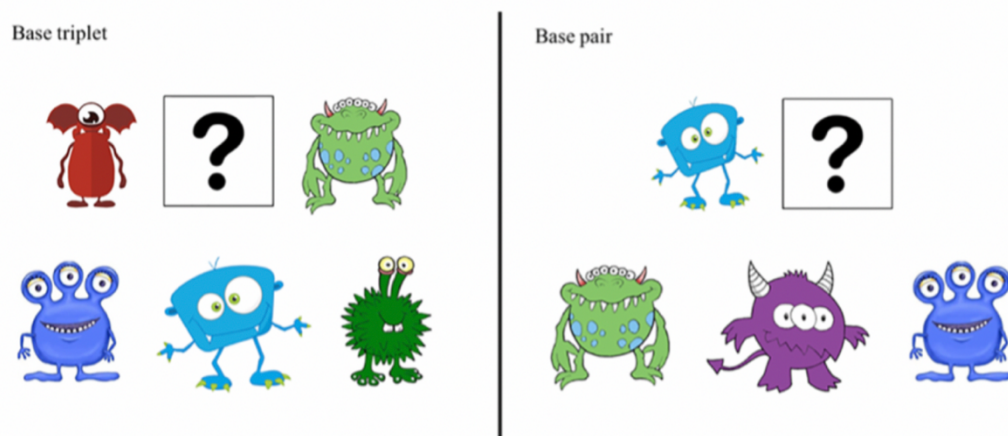


Figure 2. Example of VSL post-familiarization stimuli

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