

Dopaminergic System in Linguistic Comprehension and Grammar: fMRI study of Parkinsons Disease

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This objective of this study is how **grammar** is implemented in the brain, with special attention to a neurotransmitter *dopamine*.

Among numerous kinds of molecules known to exist in the nervous system, several molecules are known to function as “neurotransmitters”, which mediate gaps between neurons (*i.e.*, synapses) when a neuron transmits signals to another. In this study, a neurotransmitter *dopamine* is focused, as the target of the research question: *How does dopamine contribute to grammatical processing and/or grammatical working memory?*

The goal of this study is to see the relation between dopamine and syntactic phenomena well known by linguists (but not necessarily by non-linguists). These linguistic phenomena described below are part of facts about *competence*. This study aims to investigate how these parts of grammar (or competence) are implemented into the performance system (which is executed by the brain) in terms of dopamine.

Deterioration in one of the dopaminergic systems (the Nigrostriatal Pathway) is known to be the underlying pathology of Parkinson’s Disease (henceforth PD). The dopaminergic projection in the Nigrostriatal pathway is selectively and progressively deteriorated in PD. In order to compensate the loss of dopamine in this system, patients of PD are typically medicated with a dopamine precursor L-dopa (transformed into dopamine within the brain by a single catalytic process).

In the current study, PD subjects will be fMRI scanned during medication (ON-state) and during suspended medication (OFF-state). Patients during the ON-state will be assumed to have sufficient amount of Dopamine in their brain, while they would not have ample amount of Dopamine during the OFF-state. In addition, age-matched non-brain damaged population group will also partici-

pate in this study. The activation patterns of the brain, with specific attention to Broca’s area, will be compared between the ON and OFF state, and the control group. It is planned to have 15 PD subjects and 15 control subjects scanned (45 scans total).

In the MRI scanner, a grammatical or ungrammatical sentences will be presented to the subjects and they will be asked to answer grammaticality judgement or comprehension questions. There will be two sets of sentences, both of which are designed to compare different kinds of ungrammaticality.

The first set of sentences compares [A] two different kinds of ungrammaticality (Principle A violation vs. Subjacency violation) and also [B] Working Memory Load. In a pilot study, it has been confirmed that different activation patterns are elicited by Principle A violation and Subjacency violation. It will be examined whether these divergent patterns can be seen during the ON and OFF state, in order to reveal dopaminergic contributions to grammar. Moreover, it was also confirmed that sentences with longer *wh*-movement evoked greater activation in the working memory loop than sentences with shorter *wh*-movement. If dopamine contributes to these sub-processings in syntactic comprehension, the activation patterns would be different among the subject groups.

The second set of sentences compare Coordinate Structure construction and Object Relative constructions. It has been found that these two constructions show different activation patterns (Keller, Carpenter, & Just, 2001). In the current study, it will be examined whether the dissociated activation pattern can be also found in PD patients (during the ON and OFF states).

References

- Keller, T. A., Carpenter, P. A., & Just, M. A. (2001). The neural bases of sentence comprehension: A fmri examination of syntactic and lexical processing. *Cerebral Cortex*, 11(3), 223-237.

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