

**Fast and slow language processing: A window into dual-process models of cognition.
Commentary on De Neys.**

Behavioral and Brain Sciences (Commentary)

Authors

Fernanda Ferreira
Falk Huettig

Institutions

University of California, Davis

Max Planck Institute for Psycholinguistics and Department of Language and
Communication, Radboud University Nijmegen

Institutional Addresses

Department of Psychology
1 Shields Avenue
University of California, Davis
Davis, CA 95618

Max Planck Institute for Psycholinguistics
Wundtlaan 1
6525 XD Nijmegen
The Netherlands

Institutional Telephone Numbers

+1(530)752-5497
+31 24 3521374

Email addresses

fferreira@ucdavis.edu
falk.huettig@mpi.nl

Homepage URLs

<https://ferreiralab.faculty.ucdavis.edu/>
<https://www.mpi.nl/people/huettig-falk>

Abstract

Our understanding of dual-process models of cognition may benefit from a consideration of language processing, as language comprehension involves fast and slow processes analogous to those used for reasoning. More specifically, De Neys's criticisms of the exclusivity assumption and the fast-to-slow switch mechanism are consistent with findings from the literature on the construction and revision of linguistic interpretations.

Main Text

Sometimes language processing can be hard. Just as many problems are easy to solve, many sentences are easy to interpret—for example, *the cat chased the dog*. Alternatively, just as some problems leave us stumped, some sentences defy our comprehension mechanisms—for example, the infamous *the horse raced past the barn fell*. For decades, psycholinguists have attempted to explain what makes sentences difficult to understand, with some models pointing to the costs of integrating information over long distances (Gibson, 1998), others focusing on the effects of the unexpectedness of each word as it is encountered (so-called “surprisal”-based models; Hale, 2016), and others emphasizing the consequences of ambiguity (Ferreira & Henderson, 1991). Here we concentrate on syntactic ambiguity because it highlights many of the issues associated with fast and slow processing.

Specifically, in his target article, De Neys challenges researchers in decision-making to reevaluate the exclusivity assumption and to specify how the switch mechanism that triggers the switch from fast to slow reasoning works. We believe consideration of these issues from the perspective of language processing could prove useful, as they have been at the center of theoretical debates in psycholinguistics.

During comprehension, the system that assigns syntactic structure, the parser, will often encounter a sequence that can be assigned more than one grammatical analysis. In those cases, given a range of linguistic biases, the parser may select an analysis that will require revision. Take the sequence *Mary believes Tom*. On the parser's first encounter with the postverbal noun phrase *Tom*, it will likely analyze the phrase as a direct object. But if the sentence continues with a verb such as *lied*, the parser has a problem: *lied* must be syntactically integrated but there is no grammatical place for it in the structure. The only solution is for the initial analysis to be revised so that *Tom* is not a direct object but rather the subject of a complement clause. Moreover, not only does the structure require revision, but the meaning must be recomputed as well, because Mary does not in fact believe Tom. These processes can be viewed within the dual-processing framework De Neys discusses, with the initial analysis being the output of System 1 and the revised interpretation the output of System 2. The first response is fast and automatic, and the second requires a slower, more deliberate mode of processing in which the structure and the interpretation are systematically undone and rebuilt.

Much debate has centered around the question of what determines the initial analysis. For the purposes of this commentary, we set that question aside to focus on the two issues De Neys considers in the target article: the exclusivity assumption and the switch mechanism. Taking exclusivity first, psycholinguists know that often an initial, intuitive analysis will align with what a more deliberate process would deliver. Sentences sometimes resolve themselves in a way that is consistent with initial syntactic expectations (e.g., *Mary believes Tom implicitly*), and with knowledge and experience, many experienced language users will succeed in obtaining the correct interpretation of even the more challenging sentences right from the start, with no need for revision. In other cases, the initial system will deliver multiple interpretations of an ambiguous sequence, which means

revision may involve a simple shift from one analysis to another. Findings from language comprehension, then, make clear that System 1 can deliver a correct analysis.

Turning now to the switch mechanism, much is known in psycholinguistics about what triggers the switch to a more deliberate, System 2 processing mode. One critical factor is a breakdown in coherence. In the case of so-called “garden-path sentences” such as *Mary believes Tom lied*, the trigger is syntactic collapse: The tree formed for the first three words cannot accommodate the verb *lied*. This breakdown in syntactic coherence shifts the parser into a repair mode in which it revisits its previous syntactic decisions, attempts new solutions, and tries to create a revised, integrated structure. In other cases, the trigger is a breakdown in semantic coherence. For example, given *Mary believes the rain...* (as in *Mary believes the rain will stop soon*), an initial analysis on which *the rain* is analyzed as a direct object can be revised when the more deliberative system detects the semantic anomaly of believing rain. This semantic incoherence will cause the parser to review its past syntactic decisions and attempt new choices that lead to a better semantic outcome. In reasoning, a switch from fast to slow processing may similarly be triggered by a breakdown in coherence, albeit at a conceptual rather than a linguistic level of representation.

Recent work on the influence of literacy can also be interpreted according to this dual processing framework and is particularly relevant for thinking about exclusivity and the switch from System 1 to 2 modes that De Neys discusses. Literacy, for instance, uniquely predicts participants’ ability to correctly accept and reject spoken sentences according to the prescriptive grammatical norms of their language (Favier & Huettig, 2021). In linguistics, such judgements are known to involve both System 1 and System 2 processes. Literacy also makes comprehension of challenging linguistic forms more automatic (as evidenced by enhanced prediction abilities, Favier et al., 2021), providing one

potential mechanism for how System 2 can, over time, turn into System 1 processing. A dual-systems approach to language processing thus has the potential to provide new mechanistic answers about the automatization of System 2 responses as well as the interplay between fast and slow systems.

In summary, our view is that a domain in which the exclusivity assumption and the switch mechanism highlighted by De Neys can be profitably scrutinized is language processing, a cognitive system that has not often been invoked in discussions of System 1 and System 2 processing and the coordination of their outputs. We believe that considering language processing through the lens of this dual-processing framework will help to illuminate the issues related to thinking that De Neys discusses in the target article.

Acknowledgements: none

Competing interests statement: Both authors have no competing interests.

Funding statement: Preparation of this work was supported by the National Institutes of Health/NICHHD under grant number 1R01HD100516 awarded to Fernanda Ferreira.

References

- Dabrowska, E. (2018). Experience, aptitude and individual differences in native language ultimate attainment. *Cognition*, *178*, 222–235.
- Favier, S. (2020). *Individual differences in syntactic knowledge and processing: Exploring the role of literacy experience* (Doctoral dissertation, Radboud University Nijmegen Nijmegen).
https://pure.mpg.de/rest/items/item_3262500/component/file_3262501/content
- Favier, S., & Huettig, F. (2021). Long-term written language experience affects grammaticality judgements and usage but not priming of spoken sentences. *Quarterly Journal of Experimental Psychology*, *74*(8), 1378-1395.
- Favier, S., Meyer, A. S., & Huettig, F. (2021). Literacy can enhance syntactic prediction in spoken language processing. *Journal of Experimental Psychology: General*, *150*(10), 2167-2174.
- Ferreira, F., & Henderson, J.M. (1991). Recovery from misanalyses of garden-path sentences. *Journal of Memory and Language*, *30*(6), 725-745.
- Gibson, E. (1998). Linguistic complexity: Locality of syntactic dependencies. *Cognition*, *68*(1), 1-76.
- Hale, J. (2016). Information-theoretical complexity metrics. *Language and Linguistics Compass*, *10*(9), 397-412.
- Montag, J. L. (2019). Differences in sentence complexity in the text of children's picture books and child-directed speech. *First Language*, *39*(5), 527–546.