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Consistency effects in both reading and spelling: Preliminary results of a probabilistic modeling study

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Theoretical Context

- Interactions between orthography and phonology are involved in many language processes, such as reading and spelling
- As evidenced by both behavioral [1][2] and neuroimaging [3][4] studies, **spelling and reading are highly intertwined**: representations, processes and knowledge should be considered as at least partly shared between these tasks
- However, computational models are often limited to either reading or spelling, and thus may be unable to describe the broader read-write system: **no computational model is currently able to simulate both reading and spelling**
- **Consistency effects** are valuable effects for studying orthography-phonology interactions in both reading and spelling
- Consistency: measure of variability in mapping a grapheme to phonemes and a phoneme to graphemes
- Grapheme-Phoneme (GP) consistency is a strong effect evidenced in many studies in reading [5], but Phoneme-Grapheme (PG) consistency effect still debated in reading [6]
- Both PG and GP consistency need to be further studied in spelling [7]

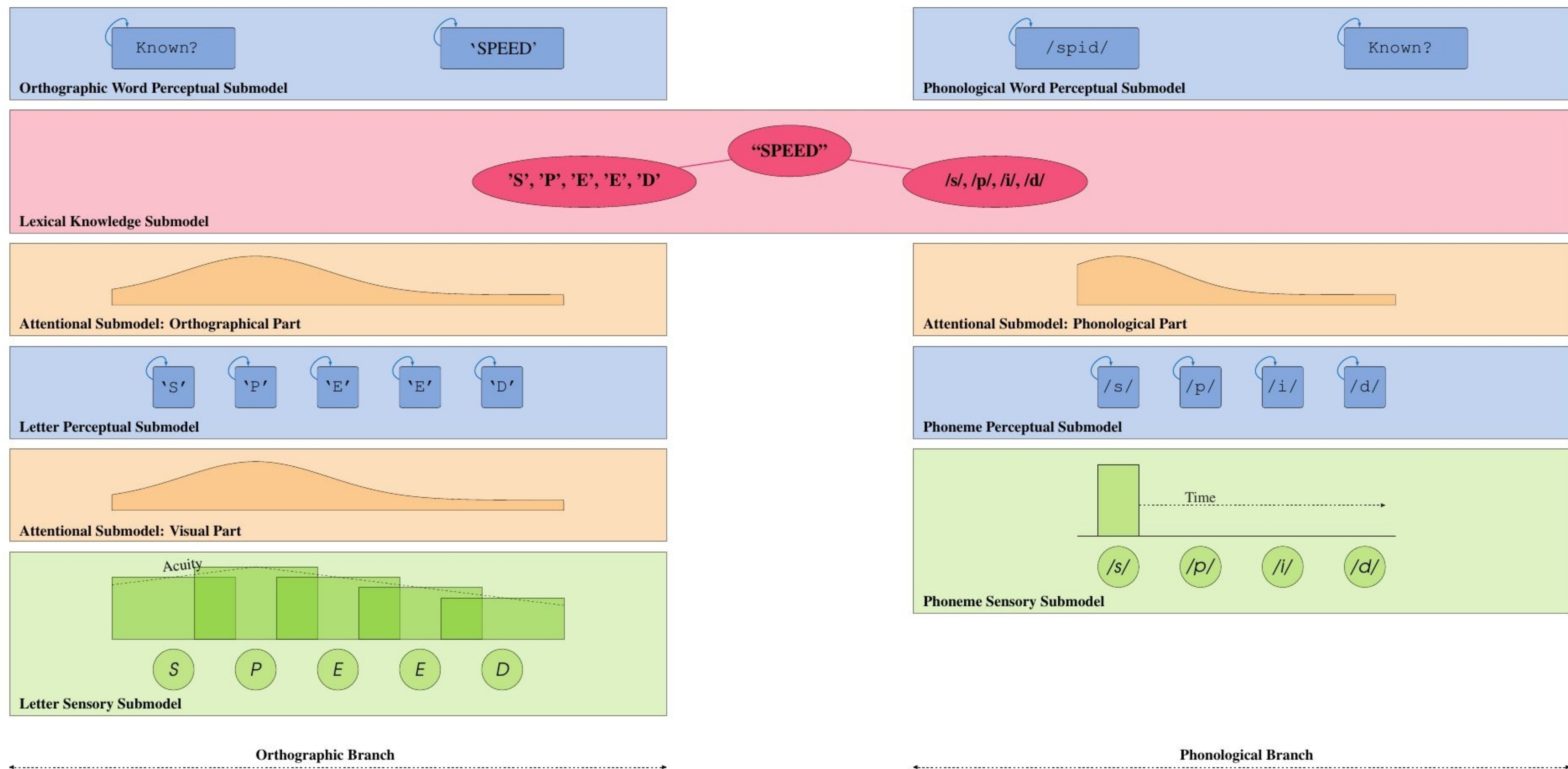
Aim of the Study

- Development of the **BRAID-Spell** (Bayesian word Recognition model with Attention, Interference, Dynamics and Spelling abilities) model
- Extension of the BRAID-Acq [8] (BRAID with reading Acquisition) model simulating reading acquisition, to spelling abilities
- First model able to simulate both reading and spelling tasks, with the same processes and lexical knowledge
- **First simulation of consistency effect in both reading and spelling**: effect of both GP and PG consistency on accuracy
- **Preliminary results**, testing the generalizability of a reading model to spelling tasks (without specific calibration)

Hypotheses

- More accurate reading than spelling, as a general effect, due to the consistency asymmetry in French
- More accurate reading and spelling of the most consistent words, compared to the most inconsistent words
- Stronger negative effect of GP than PG inconsistency for reading, and of PG than GP inconsistency for spelling

BRAID-Spell Model

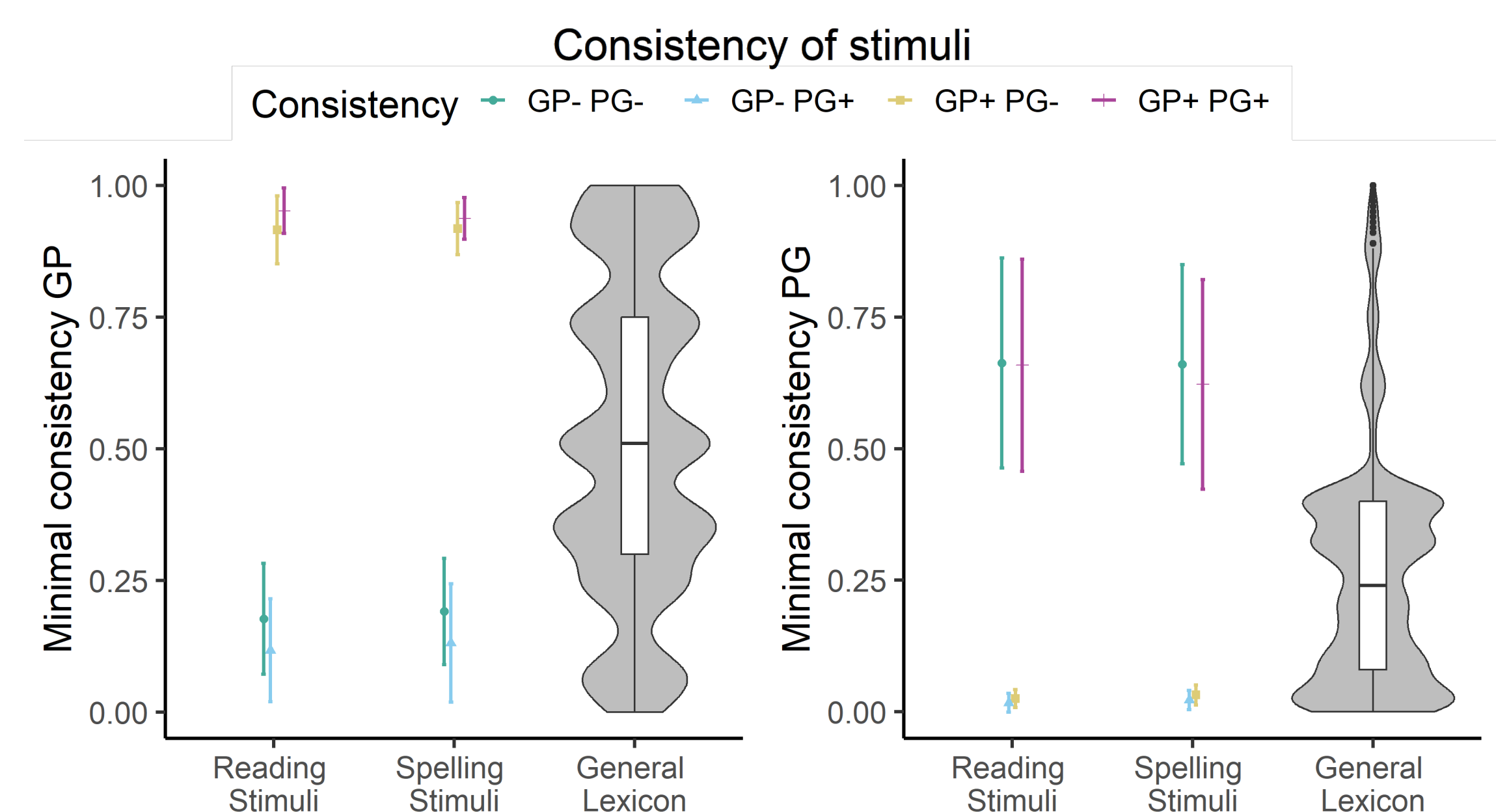


Material:

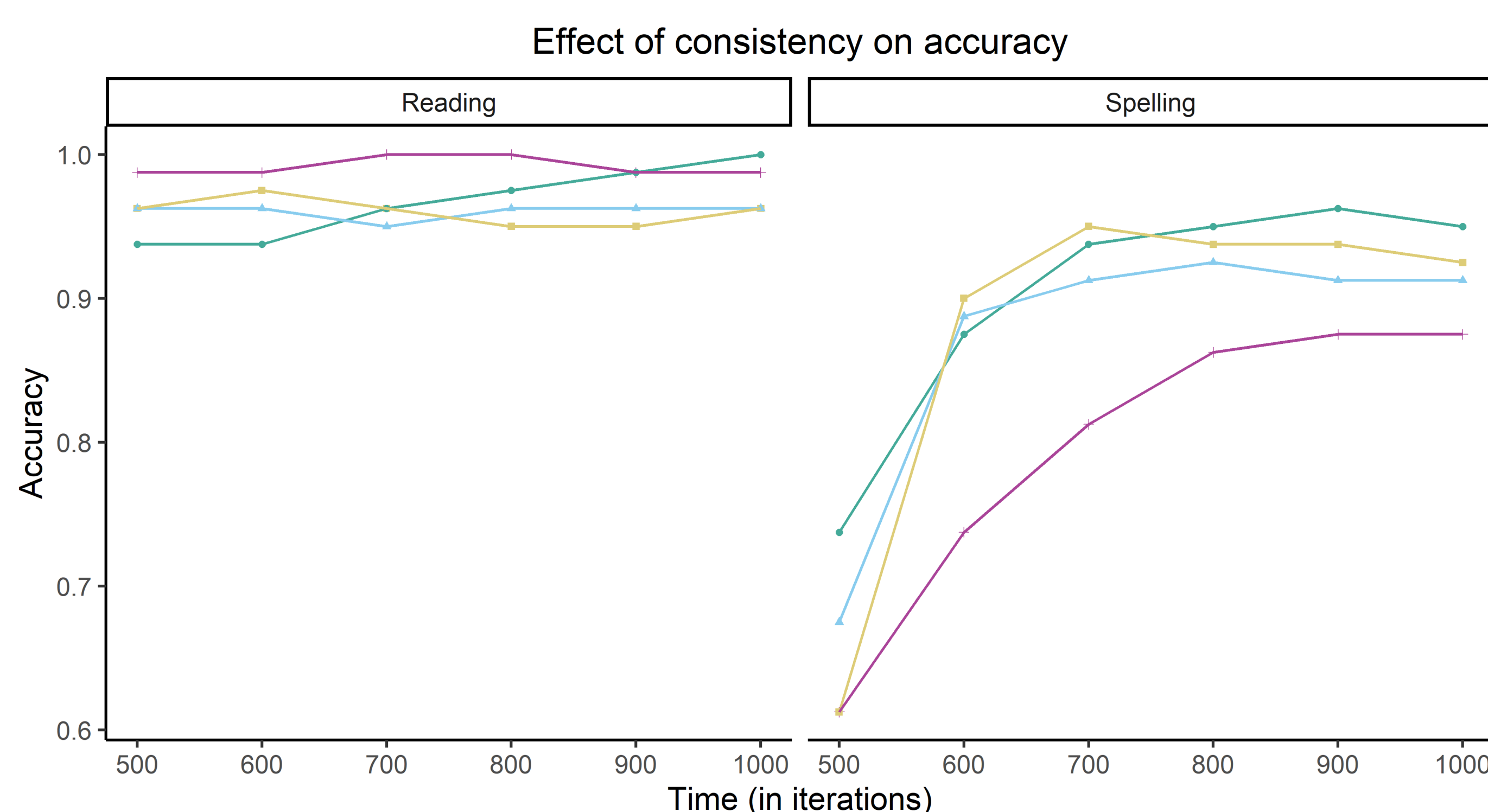
- Lexical knowledge: all lemmas (around 18,700 words) of **Lexique-Infra** [9], a French lexical database
- Consistency measure: **minimal GP/PG consistency value** of the item, as calculated in Lexique-Infra [9]
- GP/PG consistent (+) if the word minimal GP/PG consistency value is over the 3rd quartile value
- GP/PG inconsistent (-) if the word minimal GP/PG consistency value is under the 1st quartile value
- **4 consistency conditions**: GP- PG- (most inconsistent) / GP- PG+ / GP+ PG- / GP+ PG+ (most consistent)
- **4 length conditions** (by task): 4-, 5-, 6-, 7-letters (reading) or phonemes (spelling) words
- 20 words (randomly sampled on items with a frequency between 1 and 2,000 occurrences/million), for each consistency * length conditions, for each task = **320 items by task**

Simulation procedure:

- Simulations of **1,000 iterations**
- **Reading**: visual input, entropy-based visual-attentional exploration [8]
- **Spelling**: auditory input, phonemes presented in a sequence
- **Production accuracy**: correct pronunciation/spelling of the item or of an existing homographs/homophones
- Calculate accuracy at multiple time steps: every 100 iterations between 500 and 1,000 iterations



Preliminary Results



- **Correct overall performance in both reading and spelling** (<10% of errors after 700 iterations for spelling, and after 500 iterations for reading)
- **Effect of task**: better accuracy for reading (97.8%) than spelling (91.6%)
- Larger time effect on accuracy for spelling than reading: mainly due to more sequential processing for spelling
- **In reading, overall consistency effect** with better accuracy for GP+ PG+ items (except at iteration 1,000), but **no effect of the type of inconsistency** between GP+ PG- and GP- PG+ items
- **In spelling, unexpected consistency effect**, with a reversed overall effect (GP+ PG+ items spelled less accurately than others)
- Lower score of GP+ PG+ items in spelling is mainly due to items ending in /e/: the model struggles to choose between the spellings "É" and "ER", and tends to write "ÉR"
- Need to further control the neighborhood frequency, as some GP+ PG+ items are lexicalized to their more frequent neighbor

Discussion

- **BRAID-Spell**, first model of both reading and spelling, with shared representations, processes and lexical knowledge
- **Successfully performs both reading and spelling**, with an overall accuracy for reading of 97.8%, and for spelling of 91.6%
- Account for the reading/spelling asymmetry in French, with more accurate productions in reading than spelling
- A calibration of the spelling processes of the model on behavioral data may increase the GP+ PG+ item spelling accuracy
- At this stage, **encouraging results** for simulating and understanding consistency effects in reading and spelling
- First step towards a computational model of the whole read-write cognitive system
- Open perspectives for the simulation of spelling-phonology interactions in various language processing tasks



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