Modeling the Effect of Lexico-Syntactic Gender on Spoken-Word Recognition

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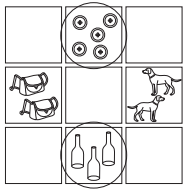
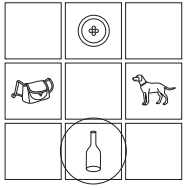
We present a pre-activation model of the gender effect in spoken-word recognition:

- **Model is a Simple Recurrent Network (Elman, 1990)**
- **Trained on French article-noun phrases, input phoneme-by-phoneme**
- **Learns to activate concepts corresponding to phoneme input**
- **Gradually centers in on lexical candidates, as humans do**
- **After training, uses lexico-syntactic gender to constrain the earliest stages of lexical access, similar to French natives**
- **Model accounts for relevant eye-tracking findings (Dahan et al., 2000)**
- **Goes beyond learning simple sequential dependencies in the input**
- **Generalizes well to novel data, including unseen article-noun combinations**
- **Discovers regularities in French gender patterns requiring an abstract notion of gender**
- **Explains mixed experimental findings in cases where the influence of gender is very subtle**

- In French, as in many other languages, nouns are subdivided into so-called "gender" classes
- Depending on gender and number of a noun, definite articles vary: "le" before masculine singular nouns, "la" before feminine singular nouns, and "les" before plural nouns of both genders
- After hearing a singular article, it is therefore in principle necessary to consider only half of the nouns in the mental lexicon
- Research clearly supports the idea that listeners use gender online to facilitate spoken-word recognition:
  - After ambiguous articles, all possible nouns are considered during lexical competition
  - After marked articles, only nouns of that category are considered as candidates



"Cliquez sur les bouteilles"
(Click on the bottles)



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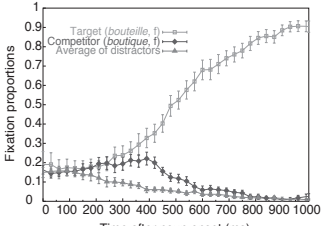
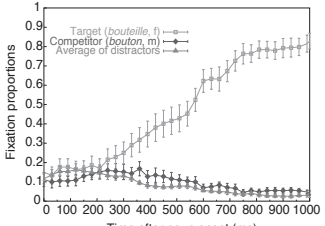
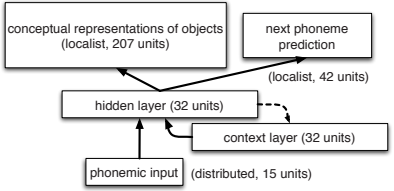


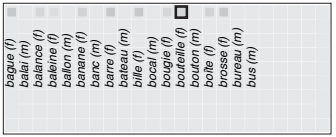


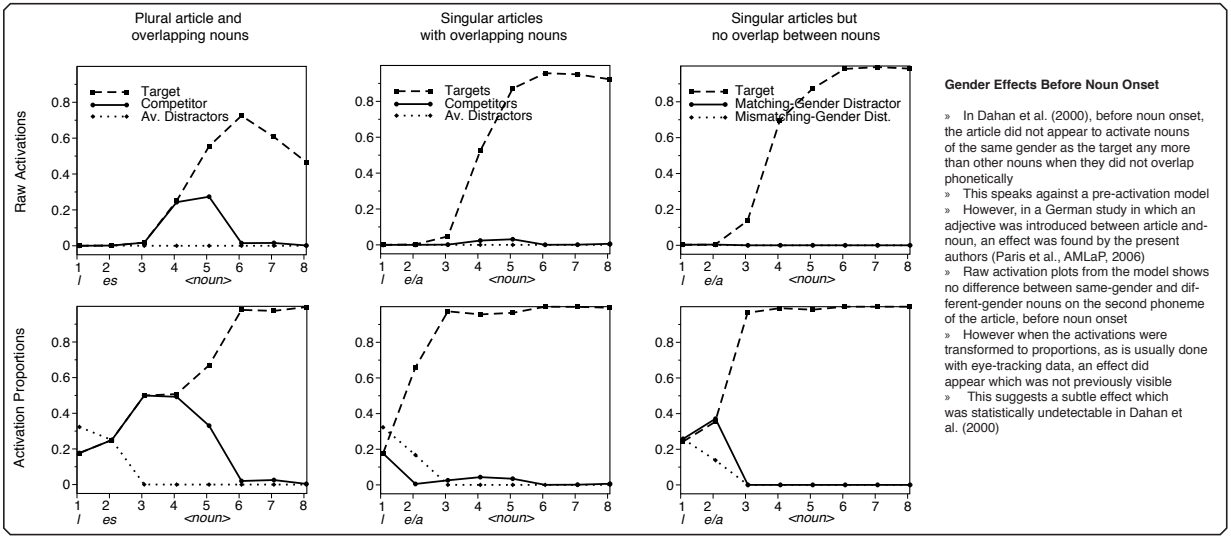
- Two explanations of the gender effect have been proposed:
  - An interactive-activation model in which the article would pre-activate all congruent nouns, giving them an early advantage over other nouns when they compete for recognition
  - A post-lexical syntactic congruency-checking mechanism
- However, some consider pre-activation inefficient because too many nouns would need to be pre-activated (Tanenhaus et al., 1987; Jescheniak, 1999)
- But it could also be seen as very efficient, since it reduces the search space in the lexicon by half
- The present model provides an implementation of a pre-activation model, showing in a simplified manner how the mechanism could potentially work

» In addition to its primary task of associating phonemic input with object concepts, the network also learns to predict the next phoneme
» Input group: Distributed phoneme representation
» Two output groups:
- Localist representation of concepts on which we observe what competitors are activated at each step in the input
- Next-phoneme prediction group
» Materials: 207 French nouns preceded by singular (gender-marked) and plural (gender-neutral) articles
» During training,
- All nouns were presented to the network with the indefinite article (“un” or “une”)
- Eighty-five percent of nouns were presented with the singular definite (“le” or “la”) and plural definite (“les”) articles
» Fifteen percent of combinations involving singular definite and plural definite articles were held back for testing (i.e. half the nouns used by Dahan et al., 2000)



» The model was evaluated by computing cosines between network activations and the probability distribution of concepts and phonemes in the training data at each phoneme in the input
» Average cosine on the training set: 0.944 (concepts) and 0.969 (phoneme prediction)
» Average cosine on the test set: 0.887 (concepts) and 0.975 (phoneme prediction)
» Given performance on novel sequences, we can conclude the network has learned that
- Nouns preceded by “un” can also be preceded by “le”
- Nouns preceded by “une” can also be preceded by “la”
- All nouns can be preceded by “les”





Gender Effects Before Noun Onset

» In Dahan et al. (2000), before noun onset, the article did not appear to activate nouns of the same gender as the target any more than other nouns when they did not overlap phonetically
» This speaks against a pre-activation model
» However, in a German study in which an adjective was introduced between article and-noun, an effect was found by the present authors (Paris et al., AMLaP, 2006)
» Raw activation plots from the model shows no difference between same-gender and different-gender nouns on the second phoneme of the article, before noun onset
» However when the activations were transformed to proportions, as is usually done with eye-tracking data, an effect did appear which was not previously visible
» This suggests a subtle effect which was statistically undetectable in Dahan et al. (2000)