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Differential use of Transitional Probabilities and Frequency in Statistical Learning of Pseudowords

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Introduction

The ability to learn transitional probabilities (probability of a stimulus given a preceding stimulus) and frequency of the sequence is central to language processing (Saffran, Newport, & Aslin, 1996; Pacton & Perruchet, 2008; Gebhart, Newport, & Aslin, 2009; Thiessen, Kronstein, & Hufnagle, 2013).

These **two factors** (Transitional Probability and Frequency) have generally been studied separately in statistical learning of sequences, although they could interplay. For instance, a few studies that have addressed the combined effect of both transitional probabilities (TPs) and frequency have suggested a prevalence of TPs over frequency (Endress & Langus, 2017; Mirman, Graf Estes & Magnusson, 2010; Perruchet & Poulin-Charronnat, 2012; Lazartigues, Mathy & Lavigne, 2021). Nevertheless, the role of the type of task on the use of these factors was not studied yet.

The present study investigated the role of transitional probabilities and frequency in pseudoword learning through two tasks.

Our hypothesis was that one or the other statistic can be used depending on the task, with a use of TPs in a task involving prediction and a use of frequency in a task involving recognition.

Method

30 participants completed the two tasks.

Detection task

16 pseudowords composed with three syllables were constructed with a manipulation of TPs and frequency.

Participants had to detect two vowels appearing only in the last syllable (fully predictable based on TPs) of each pseudoword. The target vowels could be, for example, either "e" or "u", each associated with a specific key. Participants had to press the "q" key if they saw the "e" vowel and press the "m" key if they saw the "u" vowel (note that the target vowels were not the same for all participants). Participants were asked to press the key as fast as possible when the vowel appeared. Correct answer rates and response times were recorded.

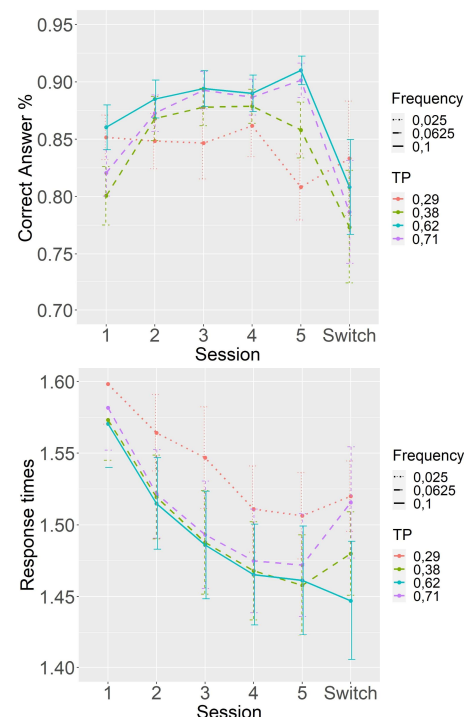
All pseudowords were presented in random order in each block. A block consisted of 80 trials and each participant completed five sessions of 10 blocks, one session per day for five days. A switch phase of 80 trials was added at the end of the last session (corresponding to a switch of the last stimuli to reset the TPs to zero in order to test participants' learning).

2AFC task

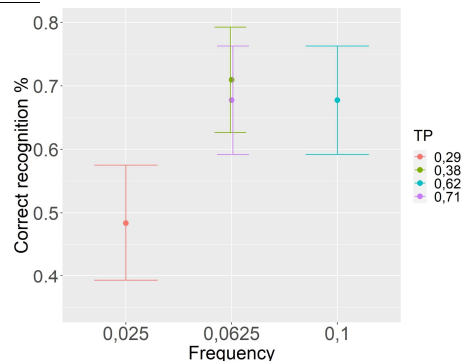
After the first task, a two-alternative forced-choice recognition task was conducted. Participants were asked to choose between the learned pseudowords, and lures constructed using the same syllables as in the learned pseudowords but in different combinations.

Figures

Detection task



2AFC



Results

We selected only pseudowords allowing a dissociation of TPs and frequency.

Detection task

The results showed that a low-frequency pseudoword resulted in lower accuracy (resulting in an absence of drop in performance during the switch phase). Furthermore, for equal values of frequency high enough to benefit learning, the results showed an effect of first-order TPs on accuracy, with higher performance for higher TPs (but with no significant effect on RTs).

2AFC

A too low frequency appeared to hinder the learning of pseudowords.

Model comparison

In order to test the involvement of TPs and frequency in each task, an Akaike information criterion (AIC, Akaike, 1987) was computed for three models for each task, including TPs or Frequency or TPs × Frequency. The AIC allowed us to determine which model best explained the results, with a lower AIC corresponding to a better model (more parsimonious).

For the correct answer rate in the detection task, the best model corresponded to the model including only TPs (AIC = -1098 versus AIC = -1113 for the models including frequency and no lower score for the model including both frequency and TPs).

Conversely, for the correct recognition rate in the 2AFC task, the best model corresponded to the one including only frequency (AIC = 179 versus AIC = 183 for the two other models).

Conclusion

Two tasks were used (detection task and 2AFC task) focusing on either online prediction or memorization and showed stronger effects of TPs or frequency, respectively.

The results suggested that both TP and frequency were learned during the experimental sessions but that participants did not use the same statistic in the two tasks. Thus, the information used by participants depends on the task at stake. The present study highlights the relationship between task properties and information used :

- The detection task allowed prediction of a stimulus from the preceding one. In that case, the TP was the information used by participants. When prediction can help online processing of sequentially presented stimuli, the TP appeared to be the relevant information about which stimulus will come next in the sequence.

- Conversely, the 2AFC task required offline recognition of pseudowords (triplets of syllables presented at the same time) and hence did not require predicting a stimulus from the preceding stimuli. In that case, frequency had a stronger effect on recognition than TP. When learning is tested offline, the frequency becomes more relevant than TP and influences recognition, as is the case in word reading (Albregues et al., 2019).

This differential use of TP or frequency is in line with Thiessen et al. (2013) view that frequency and TP are involved in different types of statistical learning mechanisms. Further, our results show that TPs and frequency are both learned, based on a single set of stimuli. But, the use of one or the other depends on the task, depending on whether it requires recognition or prediction.

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