Effects of associative (sequential) learning across speech perception, speech production, reading, and typing

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Humans have an undoubted propensity for learning associations across stimuli. As a sequential stimulus, language is perhaps the most uncontroversial domain where associative learning is at work. Indeed, there is ample evidence of the effect of associative and statistical learning on language, such as mapping object labels to referents (Hay, Pelucchi, Graf Estes & Saffran, 2010) and acquiring syntax (Kidd, 2012). Nevertheless, exactly how widespread the effect of statistical learning is on different linguistic processes and whether the same effects are seen across these processes remains unclear. In this paper we examine whether associative learning is apparent across the four basic domains of language processing (reading, writing, speech production and speech perception) and if so, how the subsequent processing of linguistic stimuli is affected.

24 high frequency target bigrams (e.g., *pocket money*) were extracted from the British National Corpus that occurred 150 times or more and that did not exist in their reverse format (zero frequency target bigrams e.g., *money pocket*). Filler items were also extracted that did not appear as a bigram with any of the target bigram words. For speech perception, 48 four-word (filler *target bigram* filler e.g., teacher *pocket money* principle) segments were spoken aloud in background noise (DV = proportion correctly recalled). For speech production, the four-word segments were displayed on screen with spoken recall accuracy recorded. For typing, the four-word segments were typed immediately after their presentation. For reading, two blocks of the four-word segments (one high frequency, one zero frequency) were flanked by additional fillers with fixation duration recorded. For reading and typing, an intermittent recognition task also took place.

Across all tasks there was an effect of bigram frequency, though this was evidenced in different ways. Relative to zero-frequency bigrams, a greater number of high frequency bigrams were perceived, produced and typed, while reading showed shorter first-fixation durations for the first word of a high frequency bigram. Processing of high frequency bigrams also facilitated processing of the following fillers, with a greater number of fillers being perceived and produced. Analysis of the recognition task showed that in both cases, words from high frequency bigrams were better remembered than those from zero-frequency bigrams, with no effect on recognition of the fillers.

We show that statistical learning has an effect for the same words across four different language domains. Moreover, the processing of high frequency bigrams facilitates the processing of subsequent language stimuli. Interestingly, this latter effect is not also borne out in the recognition data, illustrating that while there is an immediate processing advantage for stimuli appearing after a high frequency bigram this is not retained after the particular word set has been processed. Our results provide further support for the idea of now-or-never processing in language stimuli (Christiansen & Chater, 2016).

Christiansen, M. H., & Chater, N. (2016). The Now-or-Never bottleneck: A fundamental constraint on language. *The Behavioral and Brain Sciences*, *39*, 1–72.

Hay, J. F., Pelucchi, B., Graf Estes, K., & Saffran, J. R. (2010). Linking sounds to meanings: Infant statistical learning in a natural language. *Cognitive Psychology*, *63*, 93–106.

Kidd, E. (2012). Implicit statistical learning is directly associated with the acquisition of syntax. *Developmental Psychology*, *48*, 171–84.