Cascaded processing in language production is modality independent: Evidence from picture naming in American Sign Language

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There is evidence from spoken languages that information moves through the language production system in an incremental and cascaded fashion, with subsequent processes beginning before earlier ones are complete [e.g., 1–7]. Are these informational cascades modality independent, suggesting that they are a fundamental consequence of the structure of the human language system? Or are they a product of the way that lexical and phonological representations are stored and accessed in spoken language? In the present study, we used a picture naming task to investigate whether there is cascaded processing in American Sign Language (ASL) production. We focus on one prediction of the cascading architecture: Phonological form activation begins while lexical selection is still underway, leading to interactions between variables that influence these processing stages [8]. In particular, we investigated the influence of image codability (name agreement) and name frequency on naming response time (RT). These factors have been argued to influence lexical selection and phonological encoding, respectively [9–12], and they have been found to interact in spoken languages in a way consistent with cascading activation [8].

Method. Data collection is ongoing (13 of 20 completed). Our sample reported here (N = 31) comprised participants from an experiment we conducted (n = 10 collected and transcribed) and from [13]'s ASL picture naming study (n = 21; [13] analyzed codability and frequency effects but did not look for their interaction). Participants were adult native and early-exposed ASL users. In both experiments, participants were presented with images that they were instructed to name as quickly as possible. Image codability was assessed based on participant responses. For each experiment, we calculated image h-scores (larger scores = less name agreement; 0 = perfect name agreement) [14]. Since the maximum possible h-score is dependent upon sample size (which differed between experiments), we represented codability as h-score proportion (h-score / maximum h-score for the experiment). Frequency scores were derived from ASL-LEX (z-scored subjective frequency ratings) [15].

Results/Discussion. In line with previous work, we observed significant overall effects of codability ($p < 0.0001$) and frequency ($p < 0.0001$), with slower naming RTs for images with low codability and low frequency names (Fig. 1b–c). We fit ex-Gaussian distributions [16–17] to analyze how codability and frequency manipulations affect the RT distribution [8]. Codability and frequency influenced the RT distributions differently, supporting the interpretation that the factors influence different processing stages (Table 1). The factors influenced the same properties of the RT distribution as in [8], though codability had a less pronounced skew effect in the current sample. Crucially, we observed a significant interaction between codability and frequency such that the effect of frequency was smaller when codability was low ($p < 0.01$) (Fig. 1d). This interaction resembles those identified by [8] across several spoken languages and in English-speaking children. Our results illustrate that cascaded processing is a fundamental property of the human language system, a by-product of the mind's architecture that is present across language modalities. The present study further informs our understanding of the temporal dynamics of lexical access (which has historically been shaped by spoken language research) and elucidates the fundamental, modality- and language-independent properties of the language production system.

Figure 1.

a) RTs by codability x freq. category
(see Table 1 for category cut-offs)

b) Codability effect plot
RT increases as h-score prop. increases (codability decreases)

c) Frequency effect plot
RT decreases as frequency score increases

d) H-score proportion x Frequency
The frequency effect attenuates as h-prop. increases (codability decreases)

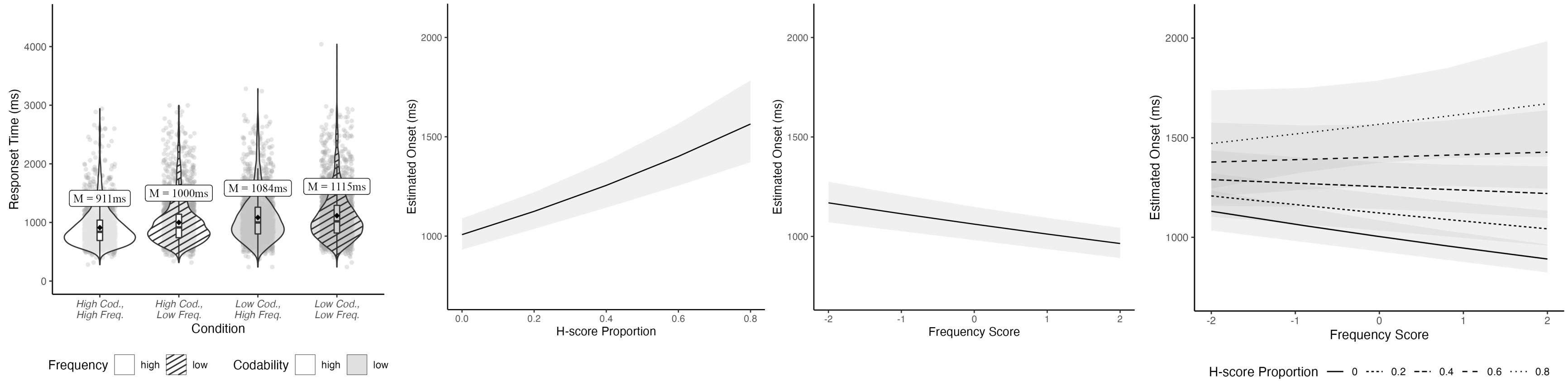

Table 1. Mean RT and ex-Gaussian parameters by condition (in ms). We categorized our data into low and high codability and frequency conditions and fit ex-Gaussian distributions to individual participants' RT data in each condition. Items were categorized as high codability if they had an h-score proportion < 0.06 (e.g., [8]). Responses were categorized as high frequency if they had a frequency rating z-score > 0.

Factor	**Condition**	**RT**	**Mu (shift)**	**Tau (skew)**	**Sigma (SD)**
Codability	Low	1120	821	320	121
	High	964	728	267	64
	Low - High Diff	156 ***	93 ***	53 ***	57 ***
Frequency	Low	1052	760	330	71
	High	1005	738	294	79
	Low - High Diff	47 ***	22 .	36 **	-8 n.s.

Note. P-value notation: n.s. = not significant, . = 0.07, ** < 0.01, *** < 0.001

References. [1] Costa et al., 2000; [2] Cutting & Ferreira, 1999; [3] Jescheniak & Schriefers, 1998; [4] Morsella & Miozzo, 2002; [5] Peterson & Savoy, 1998; [6] Rapp & Goldrick, 2000; [7] Starreveld & La Heij, 1995); [8] Kandel & Snedeker, 2023; [9] Alario et al., 2004; [10] Lachman et al., 1974; [11] Griffin, 2001; [12] Griffin & Bock, 1998; [13] Sehyr & Emmory, 2022; [14] Snodgrass & Vanderwart, 1980; [15] Sehyr et al., 2021; [16] Radcliff, 1979; [17] Balota & Spieler, 1999