

## How to deal with invariance? Rapid belief update about syntactic and prosodic cues

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For successful communication to take place, listeners have to extract the message intended by their interlocutor out of the noisy percept they receive as input. Work over the last decades strongly suggests that listeners rely on a variety of probabilistic cues in order to achieve this (e.g. Altman and Steedman, 1988; Arnold et al., 2003; Garnsey et al., 1997; Hare et al., 2003; Kamide et al. 2003; MacDonald et al., 1994; Staub and Clifton, 2006; Trueswell et al., 1994). Going beyond ‘merely’ *successful* understanding, there is also evidence that listeners rely on probabilistic cues to build expectations about upcoming words and structures, thereby allowing *efficient* language understanding (Hale, 2001, 2003; Levy, 2008, 2009; Smith and Levy, 2009).

One striking property of language that seems to be at odds with the reliance on probabilistic cues is the well-known ‘lack of invariance’ (e.g. Perkell & Klatt, 1986): the speech signal is highly variable so that different speakers have different pronunciation preferences, different syntactic subcategorization preferences, and so on. Even the same speaker may change her preferences depending both linguistic and non-linguistic contextual factors. If speakers’ output distributions change depending on a complex set of contextual factors and if speakers have different output preferences (or, put more neutrally, different distributions of possible linguistic realizations given an intended message), then comprehension may actually suffer from relying on the assumption that ‘one-size-fits-all’.

Listeners seem to deal with this problem in two ways: they keep rich records of speaker-specific experiences (e.g. Goldinger, 1996, 1998; Sumner & Samuel, 2005) and they rapidly adapt to novel speakers/situations.

Here, I focus on the later strategy. While a considerable body of work has investigated phonetic adaptation (rapid changes in the mapping from acoustic cue dimensions to phonemes), comparable work on other levels of linguistic representation, including syntactic or prosodic adaptation, has been rare or lacking. I’ll summarize research conducted in my lab that suggests that listeners adapt their syntactic expectations in ways similar to phonetic adaptation – both types of adaptation exhibit the hallmarks of rational learning under uncertainty (cf. Jacobs, 2002). Together with evidence from phonetic adaptation, these studies suggest that listeners are continuously updating their beliefs about contextually conditioned linguistic distributions (Farmer, Fine, and Jaeger, 2011; Fine and Jaeger, submitted; Fine, Qian, Jaeger, and Jacobs, 2010; Kleinschmidt and Jaeger, 2011; Snider and Jaeger, submitted). Listeners are capable of rapidly adapting to novel speakers and situations and these adaptations seem to persist (Fine and Jaeger, 2011; i.e. they are not just due to short term ‘priming’, but rather reflect a form of learning, consistent with e.g. Bock and Griffin, 2000; Chang et al., 2006; Jaeger and Snider, 2008).

I close by presenting a re-analysis of comprehension experiments on listeners’ sensitivity to prosodic cues in terms of adaptation and belief update throughout the course of the experiment.