perfect, but auditory context effects may prevent that perfection from being achieved. Other, non-auditory context effects will not, because they affect only bias and not sensitivity.

It's good . . . but is it ART?

Paul A. Luce,[a] Stephen D. Goldinger,[b] and Michael S. Vitevitch[c]

[a]*Department of Psychology and Center for Cognitive Science, University at Buffalo, Buffalo, NY 14260;* [b]*Department of Psychology, Arizona State University, Tempe, AZ 85287;* [c]*Speech Research Laboratory, Indiana University, Bloomington, IN 47405.* **paul@deuro.fss.buffalo.edu wings.buffalo.edu/~luce goldinger@asu.edu mvitevit@indiana.edu www.indiana.edu/~srlweb**

Abstract: We applaud Norris et al.'s critical review of the literature on lexical effects in phoneme decision making, and we sympathize with their attempt to reconcile autonomous models of word recognition with current research. However, we suggest that adaptive resonance theory (ART) may provide a coherent account of the data while preserving limited inhibitory feedback among certain lexical and sublexical representations.

Norris, McQueen & Cutler deserve praise for a provocative proposal. In a detailed analysis of previous interactive and modular accounts of spoken word recognition, they correctly find the models wanting: Neither the standard-bearers for autonomy nor interactionism fully explain lexical effects on phoneme decision making. However, despite their laudable treatment of the available evidence, Norris et al. take a step that may be premature. Abhorring the vacuum left by the discredited models, and invoking Occam's razor, Norris et al. reject the notion of feedback between lexical and sublexical levels of representation. Born is a presumably simpler model that merges the outputs of two autonomous stages at a new phoneme decision stage.

Although sympathetic to the authors' endeavor, we question the need for another contender in a crowded field of models. But more than this, we wonder if Occam's razor necessitates a model that rejects the notion of feedback outright and proposes a new set of task-specific decision nodes with connections configured on the fly. We suggest that a potentially more elegant – and perhaps more parsimonious – theoretical framework already exists in which the problems of lexical and sublexical interaction may find solutions, namely Grossberg's adaptive resonance theory (ART; Grossberg 1986; Grossberg et al. 1997a; Grossberg & Stone 1986; see also Van Orden & Goldinger 1994; Vitevitch & Luce 1999).

The problem of deciding between modular and interactive word recognition systems, and the consequent debate over feedback, stems from the presumption of distinct tiered levels of representation corresponding to words and pieces of words. ART provides an alternative architecture, allowing a different view of feedback. In ART, speech input activates *items* composed of feature clusters. Items in turn activate *list chunks* in short-term memory that correspond to possible groupings of features, such as segments, syllables, and words. Chunks are not fixed representations relegated to levels, as in models like TRACE or Race, but instead represent attractors of varying size (Grossberg et al. 1997a).

Once items make contact with matching list chunks, they establish *resonances* – stable feedback loops that momentarily bind the respective parts into a coherent entity. Attention is drawn to such resonant states, making them the basis of conscious experience. In typical resonance, longer chunks (e.g., words) *mask* smaller chunks (e.g., phonemes), so the largest coherent unit constitutes the natural focus of attention (McNeill & Lindig 1973). However, in procedures like phoneme identification, attention can be directed to attractors that may not represent the normally strongest resonance in the system (Grossberg & Stone 1986). Nonetheless, in this framework, responses are based on resonances between chunks and items, rather than on specific nodes arranged in a hierarchy.

ART captures the modular nature of Merge in that lexical chunks themselves do not directly facilitate sublexical chunks (hence avoiding the pitfalls of facilitative feedback discussed by Norris et al.). But ART's limited inhibitory feedback between larger and smaller chunks enables it to account for, among other things, the differential effects of subphonetic mismatch as a function of lexicality (Marslen-Wilson & Warren 1994; Whalen 1984). Briefly, when lexical chunks are strongly activated (as in W2W1 and N3W1; see Norris et al.), they dominate responding while simultaneously inhibiting their component sublexical chunks, thus attenuating effects of mismatch among the smaller chunks. However, when no lexical chunks achieve resonance (as in W2N1 and N3N1), responses will reflect the most predictive sublexical chunks. In the case of W2N1, however, masking from the weakly activated lexical chunk (W2) will slightly inhibit its component sublexical chunks, resulting in differential processing of W2N1 and N3N1. The effects of task demands and attentional focus reported by McQueen et al. (1999a) are also accommodated in the ART framework, given its facility for selective allocation of attention to chunks of various grains.

ART provides similar accounts of the data reported by Frauenfelder et al. (1990) and by Connine et al. (1997). In so doing, the adaptive resonance framework constitutes a truly parsimonious approach to the problem of lexical-sublexical interaction by eliminating hierarchical levels and by avoiding the construction of task-specific architectures. In short, Grossberg's ART is uniquely suited to accommodate the data reviewed by Norris et al., and many other data in speech-language processing. Moreover, it makes fundamentally different assumptions compared to models such as TRACE and Shortlist, which allows it to sidestep the points of contention raised by the target article. But most appealing, ART is an almost unifying theory, with applications to learning, visual perception, memory, attention, and many other domains. Unlike Merge, which casts speech perception as an insular system, segregated from general cognition, ART provides a broad framework, linking speech perception to other cognitive domains.

In the true spirit of Occam's razor, we should tolerate local complexity, such as lexical to sublexical feedback, in the interest of global simplicity. In other words, broadly appropriate constructs should be broadly applied, keeping theories consistent across the span of cognition. Feedback may be a good candidate for such inclusion. It is well-known that the brain is designed for feedback; cortical areas are reciprocally connected in complex maps, supporting resonant dynamics (Freeman 1991; Luria 1973). More important, feedback processes are central to theories across cognition, including general perception, learning, and memory. In all these domains, theorists have found feedback systems highly beneficial, and often necessary. For example, global memory models are typically cast as parallel systems, in which inputs establish resonance with prior knowledge (Goldinger 1998; Hintzman 1986; Shepard 1984; Van Orden & Goldinger 1994).

Because the "feedback hypothesis" is a centerpiece of modern cognitive psychology, perhaps Occam's injunction should lead us not to excise feedback altogether, but encourage us to explore architectures in which it functions more elegantly. We suggest that the adaptive resonance framework is such an architecture.

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