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Ambiguity, language, and cognition: Retrospect and prospect

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It was a pleasure to reread my contribution to *Advances in psycholinguistics* after nearly three decades, and to trace its relations to subsequent work. The "Mental Diplopia" (MD) in my original title (subtitle, "Towards a Model of Speech Perception at the Semantic Level") was much too cute, the idiom of a young and unseasoned explorer just setting sail on the sea of psychological thought. However, many ideas developed in MD have withstood the test of time, and some still constitute 'unfinished business' for the field today. I will focus on four such ideas and their connections to current work.

Differing types of theoretical process: Priming versus activation

MD postulated two distinct theoretical processes, and adopted two labels for the first process: preactivation and partial activation. I later came to call this process *priming* (after Lashley, 1917), but MD specified its basic characteristics in detail: a brief, 'tentative', and passive or automatic process that operates interactively, in parallel, and unconsciously. More detailed characteristics of priming were only discovered much later, again by examining effects of ambiguity. For example, MacKay (1992) used effects of ambiguity on speech errors to determine the approximate range over which priming spreads from one unit to another.

MD called the other process *activation* and both the name and the properties of activation have remained unchanged despite subsequent discovery of additional processes: As MD noted, activation has more permanent consequences than priming, is all-or-none, and integrates across the various sources of priming delivered to a semantic unit. Activation also requires a special activation mechanism, and is necessary but not sufficient for awareness (see MacKay, 1990, 1992).

Ambiguity and context effects: Lists versus sentences

MD made a clear call for further research on "factors that affect the activation component," especially the biasing effects of context. My more seasoned 1996 opinion is that these biasing factors still need further research and carry important implications for current theory.

To trace some of these implications and their relation to work on ambiguity, consider lists versus sentences, differing stimulus contexts that characterize work labeled *memory* versus *psycholinguistics*. MacKay and Bowman (1969; see also MacKay, Abrams, Pedroza & Miller, in press) noted that common open class words such as *drive* usually have only a single meaning in sentences, but have many distinct meanings when isolated within a list of unrelated words. Taken in isolation, *drive* has over 26 distinct meanings, each with one or more distinct translation equivalents in Spanish, e.g., *campaña, vigor, incentivo, manejar, empujar, llevar, forzar*, and *obligar*, meaning 'campaign,' 'personal energy,' 'incentive,' 'to drive a car,' 'to transport (passengers),' 'to traverse distance,' 'to push,' 'to compel,' 'to drive off,' and 'to drive away'. However, *drive* allows only a single meaning and only a single translation equivalent (*manejar*) within a sentence such as *Mike learned to drive a car*.

Based on such observations, MacKay and Bowman (1969; see also MacKay, 1982) demonstrated that proficient bilinguals exhibit a semantic level practice effect for translation equivalents in sentences, but not for identical translation equivalents scrambled into lists. When German-English bilinguals read a sentence in one language 12 times at maximum rate with 20s between repetitions, the time to

produce the sentences decreased as a logarithmic function of practice, and the time to produce a word-for-word translation sentence in their other language on the next 4 trials (i.e. trials 13-16) showed perfect transfer: speedup in maximum rate for the word-for-word translations was 17%, and equivalent to 16 practice trials rather than 4, a transfer effect entirely attributable to semantic level processes. However, with identical procedures for the lists, transfer for word-for-word translations was -1% and nonsignificant.

The ambiguity of words in lists also makes sense of more recent discoveries involving mixed-language lists, e.g., *drive reemplazar manejar,* versus sentences, e.g., *Mike aprendió to drive a car and began manejar to work.* Specifically, Altarriba and Soltano (1996) observed semantic facilitation when proficient bilinguals recalled RSVP lists containing translation equivalents (*drive manejar*), whereas MacKay and Miller (1994) observed semantic inhibition or blindness (i.e. reduced recall of a word preceded by a semantically identical word earlier in the sentence) for virtually identical translation equivalents in RSVP sentences. Such contrasts for lists vs sentences pose problems for current theories (e.g., Gathercole & Baddeley, 1993, pp. 8-17; Shiffrin & Nosofsky, 1994; Zhang & Simon, 1985), where short-term memory contains phonological, articulatory, or acoustic representations, but not semantic representations, and call for a new, 'distributed memory' approach (MacKay, in press; Miller & MacKay, in press). Under this approach, short-term memory is not an isolable system consisting of distinct and separate subsystems (e.g., an executive system for sentences versus a phonolgical loop for lists), but instead represents "an umbrella term for a heterogeneous array (of) capacities for temporary storage ... distributed over diverse cognitive subsystems" (Monsell, 1984; p. 328). An example theory within this 'distributed memory' approach is Node Structure theory (MacKay, 1987, 1990, 1992), where mechanisms for storing and retrieving verbal materials in lists are inseparable from mechanisms that have evolved for producing, comprehending, and representing language (see MacKay & Miller, in press a; MacKay, in press).

Inhibitory processes in cognition

MD provided an early set of empirical and theoretical arguments for 'perceptual suppression', an inhibitory process in comprehension of ambiguous sentences. Although others have since suggested a role for inhibition in comprehending ambiguity (e.g., Burgess & Simpson, 1988), I know of no other more detailed account of how these inhibitory processes may work, their consequences for perception, and their relation to psychological data. Moreover, the basic inhibitory postulates of MD, i.e. "less time is required to suppress a meaning the less its probability within a given context," and "perceiving one meaning of an ambiguity requires suppression of the other," have yet to be disproved.

There now exist whole books about inhibitory processes with roots traceable to MD, and many new inhibitory effects have been discovered. For example, MacKay et al. (in press) postulated two theoretically distinct types of inhibitory process underlying repetition blindness (RB), the reduced probability of recall for repeated letters in briefly presented words and repeated words in RSVP lists and sentences. Labeling the two types RB1 and RB2, RB1 is a type of surface blindness: it occurs for letters in words and for words in lists, it is strongly influenced by orthographic and phonological factors, it involves existing units with old or highly practiced connections, and it reflects a theoretical process whereby units undergo self-inhibition (see MacKay, 1990; and 1987, pp. 146-187).

However, RB2 is a type of deep blindness: it underlies semantic blindness (MacKay & Miller, 1994); it is mainly confined to sentence processing; and it is linked to the process of forming new connections between words and phrases in sentences, rather than to a purely inhibitory process, a refractory period effect, or perceptual fusion of repeated words (see MacKay et al., 1994; MacKay & Miller, in press b). Semantic and syntactic factors strongly influence RB2, a postulate supported by several recent results. One is MacKay and Abrams' (1994) demonstration that RB increases in magnitude when repeated words occur in familiar (syntactic/semantic) phrases such as *good night* and *night gown* rather than in lists of unrelated words. Another is Abrams, Dyer, and MacKay's (1996) significant

increase in RB for RSVP screens that were phrase-incongruent, or contained non-phrases, as in *(They wanted to)(play sports but)(sports were not)(allowed)*, versus phrase-congruent, or contained complete phrases or syntactic constituents, as in *(They wanted)(to play sports)(but sports)(were not allowed)*. This effect indicates that RB2 responds to syntactic/semantic factors, decreasing or increasing in magnitude depending on whether RSVP procedures make it easier or more difficult to form word-to-phrase links (see MacKay & Miller, in press b, and Miller & MacKay, in press, for similar 'repetition deafness' effects that likewise comport with semantic blindness, with semantic and syntactic effects in RB2, and, more generally, with the distributed memory approach to language and memory (see Miller & MacKay, 1996).

Generality of the ambiguity problem

The final sentence of MD notes possible implications of ambiguity for other aspects of thought and perception. Subsequent work has sustained these implications. For example, MacKay (1987, p. 138) developed a general, theoretically based definition of ambiguity that applies across all language and cognition, including, e.g., phonological processing in speech perception. To concretely illustrate how ambiguity raises general issues, MD discussed relations between ambiguity, attention, and memory in dichotic listening tasks, ideas later developed in my "Aspects of the theory of comprehension, memory and attention" (1973). "Aspects" focused on three different types of ambiguity as analyzed in linguistic theories of its day, but neither MD nor "Aspects" prepared me for the quite different type of ambiguity (unimagined in 1970) investigated in MacKay and Fulkerson (1979), MacKay (1980a, b, c; 1983), and MacKay and Konishi (1994). Results for this unique type of ambiguity, known as 'generic he', surprised me, overturning the carefully developed and defended processing assumptions in MD (see MacKay, 1980c; 1983) as well as extant views on how pronouns are processed in language comprehension (see e.g., MacKay, 1983) and production (MacKay & Konishi, 1994). The

results even carried implications for effects of language on behavior, and for relations between language and other aspects of cognition, including social attitudes, personal feelings and motivation, cognitive styles, and descriptive versus evaluative thought. In retrospect, MD was overly modest in limiting the theoretical implications of ambiguity to "general aspects of all thought and perception." But then retrospect is so much easier than prospect.

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