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Compound frequency effect in word production: Evidence from anomia

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The issue of what kind of frequency affects compound word (e.g., "butterfly") production has recently received special attention in the context of distinguishing two major types of speech production models. The frequency effect is widely assumed to originate from the lexical system (Jescheniak & Levelt, 1994), and one model (IN, Caramazza, 1997) predicts that the frequency of the compound words themselves ("butterfly") determines naming performance and another model (WEAVER++, Levelt, Roelofs, & Meyer, 1999) predicts the frequencies of the constituents (/butter/ and /fly/) are the effective frequency. Such predictions are deduced from the following combinations of assumptions of the two models. WEAVER++ assumes that compounds are decomposed into its constituents at a lexeme level where phonological (or orthographic) forms are represented, and this is also the level at which frequency effect locates. IN assumes that a compound is represented by one node ("butterfly") in its only lexical layer, which is also the locus of the frequency effect. Chronometric studies have yielded inconsistent results (e.g., Bien, Levelt, & Baayen, 2005; Janssen, Bi, & Caramazza, submitted for publication).

Here we present convergent evidence from the perspective of aphasia. It has been assumed that the same mechanism underlie the frequency effect in predicting the naming latencies of unimpaired speakers and the frequency effect in affecting the accuracy of anomic patients (see Miozzo, Jacobs, & Singer, 2004; Nickels, 2001). We report two Chinese patients with whom we studied oral compound production and written compound production respectively. The question is whether compound frequency or the frequencies of the constituents best predict the naming accuracy in the two modalities of output.

Case report

GXM is a 51-year-old right-handed man with a high school education. He suffered from an internal hemorrhage in the left temporal lobe causing aphasia and right hemiplegia. GXM was able to repeat single syllables (8/8) and his word comprehension was relatively spared: word–picture matching (auditory: 24/25; visual: 25/25). He was perfect in a nonverbal semantic task (30/30), where he needed to select from two pictures (e.g., rail and road) the one that is semantically closer to a target picture (e.g., car). His oral picture naming performance was poor (25%, 58/232) and made frequent semantic, phonological, visual, and circumlocution errors.

SJS is a 57 year-old man with a college education. He was flawless in auditory and visual comprehension tasks: auditory word lexical decision (20/20), word–picture matching (auditory: 49/50, visual: 15/15). He was also relatively spared with oral production tasks, including repetition (40/40), oral word reading (45/45), and oral picture naming (noun: 31/34; verb: 32/34). He was perfect in direct copying (50/50) but was impaired in written picture naming (70%, 163/232), making semantic, phonological, and omission errors.

Both patients were given two sets of compound naming tasks where object pictures whose names are bisyllabic compound words were presented and the patients were either asked to name the pictures orally (GXM) or to write down the names (SJS) (see Table 1 for the design and sample stimuli). In Set 1, both compound frequency and constituent frequencies were manipulated, generating three lists of pictures: High compound frequency with high constituent frequency (H-hh); Low compound frequency with low constituent frequency (L-ll); and low compound frequency with high constituent frequency (L-hh). In Set 2, the compound frequencies were controlled for and the constituent frequency at the two positions of the compounds were manipulated orthogonally, constructing four lists of pictures, testing any potential headness effect on the compound frequency effect. These four lists were matched on naming agreement and familiarity ($ts < 1$).

The naming performances of the two patients on these two sets are given in Table 1. For Set 1, both patients named H-hh pictures better than L-hh and L-ll pictures (GXM: $\chi^2(1) = 9.37$, $p < .01$; SJS: $\chi^2(1) = 5.72$, $p < .05$). No differences between L-ll and L-hh pictures were observed for either of the patients ($\chi^2 <= 1$; $ps > .3$). The four lists in Set 2 also yielded comparable accuracy ($ps > .2$).

Discussion

GXM and SJS had difficulty in lexical access for oral production and written production, respectively. We have shown that the frequencies of the compound words themselves, but not the frequency of the constituent morphemes, affect the naming performances of both patients. These results challenges the theory (Levelt et al., 1999) that assumes decomposed access of compounds and that the frequency effect originates from such decomposed components (lexemes), and are consistent with the theory (Caramazza, 1997) that assumes only one lexical level during word production and that compounds are represented by their own lexical nodes at this level.

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Table 1
GXM's and SJS's compound production performances in the picture-naming task

	Example	Compound frequency/1st constituent frequency/2nd constituent frequency[a]	GXM (oral naming accuracy)	SJS (written naming accuracy)
Set 1				
H-hh	飞机 (airplane, fly-machine)	131/3690/3610	6/30	27/30
L-hh	天线 (antenna, sky-line)	10/3228/4812	1/30	21/30
L-ll	皇冠 (crown, king-hat)	8/507/492	0/30	19/30
Set 2				
HH	气球 (balloon, air-ball)	9/5214/6327	4/21	11/21
HL	手套 (gloves, hand-cover)	11/3940/493	2/21	15/21
LH	推车 (cart, push-car)	11/678/4102	2/21	13/21
LL	烟斗 (pipe, smoke-bucket)	8/492/376	2/21	15/21

[a] Frequency indexes are counts per 1.8 million (Institute of Language Teaching and Research, 1986). The critical constituent frequency should be the phonological lexeme frequency for GXM and the orthographic lexeme frequency for SJS. Given that the lexeme frequencies for these two modalities are positively correlated, only the phonological lexeme frequencies are listed here.

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