



Assessing the effect of ambiguity in compositionality signaling on the processing of diphones



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ARTICLE INFO

Article history:

Received 10 March 2017

Received in revised form 2 March 2018

Accepted 15 March 2018

Available online 11 April 2018

Keywords:

Morphonotactics

Compositionality signaling

Ambiguity

Perception

ABSTRACT

Consonantal diphones differ as to their *ambiguity* (whether or not they indicate morphological complexity reliably by occurring exclusively either within or across morphemes) and *lexicality* (how frequently they occur within morphemes rather than across morpheme boundaries). This study empirically investigates the influence of ambiguity and lexicality on the processing speed of consonantal diphones in speech perception. More specifically, its goal is to test the predictions of the Strong Morphonotactic Hypothesis, which asserts that phonotactic processing is influenced by morphological structure, and to clarify the two conceptions thereof present in extant research. In two discrimination task experiments, it is found that the processing speed of cross-morpheme diphones decreases with their ambiguity, but there is no processing difference between primarily cross-morphemic and morpheme-internal diphones. We conclude that the predictions of the Strong Morphonotactic Hypothesis are borne out only partially, and we discuss the discrepancies.

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1. Introduction

The processing of sound sequences, and that of word-internal consonant sequences in particular, have been argued to depend, among other factors, on the morphology of words they are embedded in: some diphones, such as /ld/ or /nd/, occur across morpheme boundaries (*call+ed*, *wan+ed*) as well as morpheme internally (*cold*, *wand*), while others are restricted to a single morphological environment (/md/ as in *seem+ed*, and /mp/ as in *lamp*, respectively). This has been suggested in turn to affect their acquisition and diachronic development (Dressler et al., 2010; Korecky-Kröll et al., 2014; Leykum et al., 2015a; Zydorowicz, 2007).

This work aims at assessing the influence of morphological status of consonantal sequences on the ease of their processing in speech perception. We address this aim by means of two related experiments conducted with speakers of Polish. Our experimental setup will, more specifically, address two divergent propositions that have been drawn from – and sometimes equated with – a central hypothesis in the research focusing on the interaction of phonotactics and morphology, i.e., the morphonotactic research paradigm (see Table 1 for terminological clarification). This hypothesis in a nutshell asserts that sound sequences may have the function of signaling morpheme boundaries and triggering the decomposition of a complex word. Above the morphological level, it is well known that phonotactic knowledge helps listeners in the decomposition of the speech stream into words (McQueen, 1998; Mattys et al., 1999; Mattys and Jusczyk, 2001; Daland and Pierrehumbert, 2011;

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van der Lugt, 2001). Thus, sound sequences which rarely occur within words function as boundary signals and thus speed up the parsing process. In morphonotactics, this principle is transferred to the word-internal domain, that is, the decomposition of words into morphemes. There is experimental support for the influence of phonotactic probability on decomposition, at least in derivational morphology (Hay, 2003).

Put into semiotic terms, sound sequences are hypothesized to function as *signifiants* for the *signifié* ‘morphological boundary’ (Dressler and Dziubalska-Kořaczyk, 2006). If sound sequences indeed fulfill this semiotic function, then the reliability of this function and by consequence the ease of processing of boundary spanning sequences should be diminished as soon as signaling becomes ambiguous (in the sense that the same consonant sequence can be additionally used within morphemes). The question is whether the latter condition holds true. This is what we test in our first experiment. In the second experiment we consider the question of whether the ambiguity of a sequence in general affects its processing. The subtle difference between these two questions, which have both been addressed but not always clearly distinguished from each other in morphonotactic research, is this: The former is about the effect of ambiguity on the quality of a sign, which as a consequence is expected to affect the processing of a sequence (the sign’s *signifiant*; ‘Is the boundary-signaling sequence /md/ in *seem+ed* processed faster than /nd/ in *wan+ed*?’). The latter considers the effect of ambiguity on the processing of a sequence without being restricted to denoting a morpheme boundary (‘Is /md/ generally processed faster than /ld/, irrespective of whether /ld/ occurs in *call+ed* or in *cold*’).

We will show that the central hypothesis is confirmed by our experiments, albeit only partially: boundary-spanning instances of diphone types (such as /ld/ in *called*) are processed most slowly if the type occurs across morpheme boundaries and within morphemes at roughly equal frequencies (e.g., /ld/ in English). Thus, speakers have probabilistic knowledge of the morphological environment of diphones. We argue that this suggests a cognitive model of phonotactics in which memories of instances of sound strings are stored together with morphological information (Plag et al., 2017). We do, however, not find a general advantage of non-ambiguous (/md/) over ambiguous (/ld/) diphone types if cross-morpheme instances are not explicitly tested, nor did we detect a general advantage of primarily boundary spanning (/md/) over primarily morpheme-internal (/rl/) diphone types (or the reverse).

In our analysis, we employ two ways of measuring ambiguity of signaling morpheme boundaries, differentiating between type and token frequencies. In order to detect potentially nonlinear effects of ambiguity, we use generalized additive models (Wood, 2006), a modeling technique which recently gained momentum in linguistic research (e.g., Wieling et al., 2011; Baayen, 2013; Fruehwald, 2017). Thus, in addition to providing results on the processing of sequences of sounds, this study, on a more theoretical level, seeks to highlight and clarify some of the argumentative vagueness that seems to be present in the morphonotactic literature, while at the same time featuring relatively novel analytical methods.

The cornerstones of morphonotactics will be described together with our specific research questions in the remainder of this section and in Section 2. Afterwards, the two experiments together with their analyses (Section 3 and 4) will be presented and finally discussed (Section 5).

Table 1
Phonotactic and morphonotactic terminology.

Term	Meaning	Example
<i>Diphone</i>	Sequence of two single sound segments	/hæ/, /æɪ/, and /nd/ in <i>hand</i> /hænd/
<i>Consonant cluster</i>	Sequence of consonants; sometimes restricted to sequences within syllables (not in this study)	/nd/ in <i>hand</i> /hænd/
<i>Morphonotactic instance of a cluster</i>	Token of a cluster which spans a morpheme boundary; sometimes referred to as <i>morphotactic</i> , <i>boundary spanning</i> or <i>cross-morphemic cluster</i>	/nd/ in <i>bann+ed</i> /bænd/
<i>Lexical instance of a cluster</i>	Token of a cluster which is morpheme internal; also referred to as <i>phonotactic</i>	/nd/ in <i>hand</i> /hænd/
<i>Primarily morphonotactic cluster</i>	Cluster type which has exclusively or almost exclusively morphonotactic instances; sometimes measured in type frequency rather than token frequency; also referred to as <i>morphonotactic strong default</i> , <i>prototypically morphonotactic</i> , or if token frequency is used <i>low probability</i>	Word final /ts/ as in <i>bit+s</i> or <i>cut+s</i> (but also in a few items like <i>blitz</i>)
<i>Primarily lexical cluster</i>	Cluster type which has exclusively or almost exclusively lexical instances; sometimes measured in type frequency rather than token frequency; also referred to as <i>lexical strong default</i> , <i>prototypically lexical</i> , or if token frequency is used <i>high probability</i>	Word final /lk/ as in <i>bulk</i> or <i>milk</i>
<i>Ambiguous cluster</i>	Cluster type with many morphonotactic as well as many lexical instances; also referred to as <i>mid probability</i> if token frequency is used; ambiguous clusters closer to the lexical/morphonotactic end of the cline are also referred to as <i>lexical/morphonotactic default</i>	Word final /ld/ in <i>call+ed</i> or <i>cold</i> or /nd/ in <i>bann+ed</i> or <i>bind</i>
<i>Lexicality of a cluster</i>	Fraction of lexical instances of a cluster type; usually called <i>probability</i> of a cluster type if token frequency is used	Close to 0 if primarily morphonotactic (English /ts/); close to 1 if primarily lexical (English /lk/); close to 1/2 for a perfectly ambiguous cluster (English /ld/)
<i>Ambiguity of a cluster</i>	Similarity of a cluster distribution with a 1:1 distribution of morphonotactic and lexical instances	‘High’ for a perfectly ambiguous cluster (English /ld/); ‘low’ for primarily lexical or morphonotactic clusters (English /lk/ or /ts/)

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