

Language proficiency moderates morphological priming in children and adults

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1 Introduction

A number of studies have shown that skilled readers decompose morphologically complex words upon encountering them (for a review, see Rastle & Davis, 2008). It has been proposed that this segmentation process is early and automatic and is driven by orthographic form, while being blind to semantic content, thus also called *morpho-orthographic* (Rastle, Davis, & New, 2004; Taft, 2003). One key finding in favor of this proposition comes from masked morphological priming: the recognition of a target word is facilitated when it is preceded by a morphologically related word prime (*teacher-TEACH*). Facilitation has also been found in a number of languages for targets preceded by pseudocomplex word primes that is words that appear to have a morphologically complex structure, but are simplex words (*corner-CORN*). Moreover, facilitation has as well been observed from complex pseudoword primes, that is a non-existing combination of a stem and affix (*flexify-FLEX*). For non-morphological nonword primes, that is a non-existing combination of a word and a non-morphemic ending (*flexint-FLEX*), mixed results have been obtained (Longtin & Meunier, 2005; Morris, Porter, Grainger & Holcomb, 2011). Recent evidence from French points to a moderating role of language proficiency: the magnitude to which morpho-orthographic information is used increases as a function of individual vocabulary and spelling skills in adults (Andrews & Lo, 2013; Beyersmann, Casalis, Ziegler & Grainger, 2014).

Only few studies have been concerned with morphological decomposition in beginning readers. The few studies from English and French used complex word primes, pseudocomplex word primes and non-morphological word primes. Quémart, Casalis and Colé (2011) found priming in French grade 3, 5, and 7 children from complex as well as pseudocomplex words, thus suggesting that children already use adult-like decomposition processes. In contrast, Beyersmann, Castles and Coltheart (2012) only found priming from truly complex words in grade 3 and 5 English-speaking children, indicating that morpho-orthographic priming is not automatized yet and decomposition relies more on semantics in developing readers. However, no studies with children have used complex pseudoword primes so far, although they provide the possibility to utilize the paradigm in languages that do not naturally have pseudocomplex words, such as German.

Morphological decomposition in German can be insightful to investigate, because of its language specific characteristics. German has a transparent orthography and is morphologically rich. As a consequence, morphological entities might present a very useful unit for effective word recognition, even for beginning readers. Nevertheless, for children being still in the process of reading acquisition and showing more variability in their lexical representations, language proficiency can be expected to play an even greater role than Beyersmann et al. (2014) found for adults.

The aim of the present study was therefore to test whether the moderating effect of lan-

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guage proficiency, as indexed by vocabulary and spelling skills, on morphological priming can be replicated with German adults and whether it generalizes to readers at the lower end of the proficiency range, namely children. We expect to see evidence for a more automatized form of morpho-orthographic decomposition in highly proficient children (replicating the Quémart et al. pattern), whereas low-skilled children should show less priming (as in Beyersmann et al., 2012) or no robust priming at all. In our adult group, we expect robust priming in all three prime conditions (including the nonsuffixed condition) in high proficiency participants, but reduced non-suffixed priming in low proficiency participants

2 Method

2.1 Participants

Twenty-four university students (13 women, $M_{\text{age}} = 25.2$ years, age range: 20–29 years) and 24 elementary school children (13 girls, $M_{\text{age}} = 9.5$ years, age range: 8;6–10;9 years, grade 3-5) participated in the experiment.

Each participant's language proficiency was assessed, using a spelling and a vocabulary test. Adults performed a spelling recognition test, which was modelled after the one used by Andrews and Lo (2012). Participants were asked to classify 100 words as correctly or incorrectly spelled. Children performed the fill-in-the-gap dictation test of the SLRT-II (Moll & Landerl, 2010). For assessment of vocabulary, adults completed the German version of the LexTALE (Lemhöfer & Broersma, 2012), and children the vocabulary subtest of the CFT 20 (Weiß, 1998). A composite measure of spelling and vocabulary was calculated by standardizing and averaging the spelling and vocabulary scores for each participant.

2.2 Materials

We conducted a masked priming lexical decision experiment using real suffixed words (*kleidchen-KLEID*), suffixed pseudowords (*kleidtum-KLEID*), nonsuffixed pseudowords (*kleidekt-KLEID*) and unrelated controls (*träumerei-KLEID*) as primes. 50 word targets were selected from the childLex corpus (Schroeder, Würzner, Heister, Geyken, & Kliegl, 2014) and 50 pseudoword targets were created by changing one letter from a real word that was not in the target word set. Word and nonword targets were

matched on length. For each target all four types of primes were created. Primes were matched on length, suffix length and non-morphemic ending length across conditions. Four counterbalanced lists of prime-target combinations were created, each containing a target only once, such that participants saw each target only with one of the four prime conditions.

2.3 Procedure

Stimuli were presented in white 20-point Courier New font in the center of a black screen on a 15" laptop monitor with a refresh rate of 60 Hz. Each trial consisted of a 500-ms fixation cross, followed by a 500-ms forward mask of hash keys, then a prime in lowercase for 50 ms, followed by the target in uppercase. The target remained on screen until response. Participants were instructed to indicate whether the presented stimuli was an existing German word or not by pressing a key as quickly and as accurately as possible. They were not informed about the presentation of the prime.

2.4 Results

Reaction times were analyzed using linear mixed-effects modeling. Participants and items were included as random factors and lexical status of the target (word, pseudoword), prime type (suffixed word, suffixed pseudoword, nonsuffixed pseudoword, unrelated word), age group (adults, children) and language proficiency (continuous measure combined of the spelling and vocabulary scores), as well as all their interactions, were included as fixed effects. Where appropriate, one-sided post-hoc contrasts were applied comparing all related priming conditions with the unrelated condition. For contrasting readers with higher and lower proficiency, reaction times of participants scoring one standard deviation above or below the mean proficiency measure within their age group were used. Significance was evaluated using the normal distribution. Results are reported for word targets only. Descriptive statistics are provided in Table 1.

For adults, priming was observed from all three related conditions (suffixed word, suffixed pseudoword and nonsuffixed pseudoword) relative to the unrelated condition, $z=5.04$, $z=4.43$, $z=2.07$, all $p<.05$. However, language proficiency moderated priming effects. Priming in the nonsuffixed pseudoword condition was only significant for adults with higher language proficiency (+1SD), $z=1.74$, $p<.05$, but not for adults

Prime Type	RT		Stimulus Example
	Adults	Children	
All participants			
Suffixed Word	593 (12)	1024 (36)	<i>kleidchen - KLEID</i>
Suffixed Nonword	597 (12)	1051 (38)	<i>kleidtum - KLEID</i>
Nonsuffixed Nonword	614 (13)	1045 (38)	<i>kleidekt - KLEID</i>
Unrelated	629 (14)	1087 (41)	<i>träumerei - KLEID</i>
Higher Language Proficiency (+1SD)			
Suffixed Word	588 (12)	900 (28)	<i>kleidchen - KLEID</i>
Suffixed Nonword	583 (12)	924 (30)	<i>kleidtum - KLEID</i>
Nonsuffixed Nonword	602 (12)	903 (28)	<i>kleidekt - KLEID</i>
Unrelated	620 (13)	974 (33)	<i>träumerei - KLEID</i>
Lower Language Proficiency (-1SD)			
Suffixed Word	599 (12)	1189 (48)	<i>kleidchen - KLEID</i>
Suffixed Nonword	613 (13)	1218 (51)	<i>kleidtum - KLEID</i>
Nonsuffixed Nonword	626 (14)	1239 (52)	<i>kleidekt - KLEID</i>
Unrelated	638 (14)	1229 (51)	<i>träumerei - KLEID</i>

Table 1. Response times (in ms) for children and adults, averaged across items for each participant. Standard errors are presented in parentheses.

with lower language proficiency (-1SD), $z=1.16$, $p=.25$.

For children, proficiency played an even more pronounced role than for adults: higher proficiency children (+1SD) showed the same pattern as higher proficiency adults, namely priming from all related condition, $z=3.03$, $z=2.02$, $z=2.96$, all $p<.05$. In contrast, in lower proficiency children (-1SD) priming in none of the conditions reached significance, although there was a numerical advantage from suffixed word primes in the mean reaction times (40ms faster compared to the unrelated condition).

3 Conclusion

Our results confirm recent evidence for French adults (Beyersmann et al., 2014), showing that the extent to which morphological information is exploited depends on language proficiency also in German. Adults in the present study showed morphological priming effects from suffixed word primes (*kleidchen-KLEID*), suffixed pseudoword primes (*kleidtum-KLEID*) and also nonsuffixed pseudoword primes (*kleidekt-KLEID*) relative to unrelated words (*träumerei-KLEID*). Priming from the nonsuffixed pseudoword condition did not continue to be significant with decreasing language proficiency.

Moreover, the pattern of priming generalizes to beginning readers with higher language proficiency: they show priming similar to that of higher proficient adults. For children with lower language proficiency, the effects did not reach significance, but were clearly most pronounced in the suffixed word condition.

We argue that there is a developmental gradient in the use of morphological information during reading acquisition, driven by language proficiency. Beginning readers with low language proficiency are only able to benefit from morpho-semantic information, if at all. More advanced lexical knowledge allows readers to extract morpho-orthographic information. Following Andrews and Davis (1999) and Grainger and Ziegler (2011), we assume that this happens through segmentation of the affix in lower proficiency adults, as indicated by the priming effects of both suffixed prime conditions. Crucially, higher proficiency adult and even child readers with sophisticated lexical knowledge are able to additionally use segmentation of the embedded stem, therefore showing facilitation also in the nonsuffixed prime condition. Our results highlight the importance of lexical knowledge as a further determinant of the ability to exploit mor-

phological structure in the word recognition process, especially in children.

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