

III. The acquisition and processing of (mor)phonotactic consonant clusters in German

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1. INTRODUCTION

The aims of this psycholinguistic contribution are to show how morphonotactic and phonotactic German consonant clusters differ 1) in early spontaneous first language acquisition and 2) (more importantly) in processing experiments, under which conditions one of the two cluster types is acquired earlier and processed more accurately and with shorter latency, as well as what the impact of frequency, familiarity and foreignness on the processing of simple words, compounds and morphological derivatives is.

Phonotactics and morphotactics interact in the area of morphonotactics (Dressler & Dziubalska-Kołaczyk 2006). As will be shown in the following sections of this chapter, consonant clusters with and without morpheme boundaries are a good testing ground for the investigation of morphonotactics. Whereas phonotactic consonant clusters are found in simple word stems (e.g. German *Wicht* ‘wight’), morphonotactic clusters cross morpheme boundaries in inflected, derived or compound words (e.g. German (*er/sie/es*) *mach-t* ‘(s/he/it) makes’, *Reich-tum* ‘richness’, *Pech+tag* ‘off-day’). Sometimes morphonotactic clusters are entirely new consonant clusters that can only be found in morphologically complex words (e.g. German *ruf-st* ‘(you) call’), but sometimes they may also be homophonous with existing phonotactic clusters (e.g. German morphonotactic *lob-st* ‘(you) praise’ vs. phonotactic *Obst* ‘fruit’). The question that arises is whether the interaction between phonotactics and morphonotactics facilitates the processing and acquisition of morpho-

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notactic clusters or makes it more difficult, or if it makes no difference whether a word contains a phonotactic or morphonotactic cluster. In contrast to Slavic languages, German has only very few examples of morphonotactic clusters which arise through vowel deletion, and all clusters involved are homophonous with phonotactic clusters, e.g. in the adjective *risk-ant* ‘risky’ derived from the noun *Risiko* ‘risk’. For a corpus linguistic description of complex German consonant clusters, see Dressler and Kononenko in this volume.

Previous research (Zygorowicz 2007, 2009, 2010; Kamandulytė 2006; Freiberger 2007, 2014; Korecky-Kröll & Dressler 2015; Zygorowicz et al. 2015) has shown no greater acquisitional difficulties for morphonotactic clusters compared to phonotactic clusters in typically developing children. Evidence for the facilitation of acquiring morphonotactic clusters has been found for Polish and Lithuanian, but not for German. Evidence for the ease of processing of German has been divergent (Korecky-Kröll et al. 2014; Celata et al. 2015; Freiberger et al. 2015).

The results of the above investigations have led to the hypothesis (Zygorowicz et al. 2015) that processing ease correlates with the morphological richness of the respective language. Morphological richness is defined as the amount of productive morphology (Dressler 1999, 2004), and it has been demonstrated by Xanthos et al. (2011) that its presence in child-directed speech supports children in developing and speeding up the acquisition of morphology. For processing, our corresponding claim refers to Libben’s (2014) principle of maximum opportunity.

German morphology is relatively poor in inflection, which probably explains why we have found no facilitation of the acquisition and processing of morphonotactic clusters, but it is rich in compounding and several areas of derivational morphology.

We examined the influence of (mor)phonotactics in visual word recognition in lexical access and word identification (Korecky-Kröll et al. 2014; Freiberger et al. 2015; Korecky-Kröll et al. 2016; Sommer-Lolei, Korecky-Kröll & Dressler 2017) in order to test the Strong Morphonotactic Hypothesis (Dressler & Dziubalska-Kolaczyk 2006), which claims that morphonotactic consonant clusters facilitate processing and acquisition and lead to higher accuracy because of the significant morphological information those clusters carry. We will test this hypothesis for German, to see whether it will be supported because morphonotactics facilitates word recognition in lexical processing. Or will processing rather be impeded due to the higher processing cost of inflected word forms vs. base forms? Furthermore, we hypothesize first that the Strong Morphonotactic

Hypothesis may not be equally true for all languages and may depend on the morphological richness of a language or its respective morphological subsystem; second, that factors other than the often-overestimated frequency may play a major role in processing.

2. CONSONANT CLUSTERS IN FIRST LANGUAGE ACQUISITION

Freiberger (2014) investigated the early acquisition of morphonotactic and phonotactic consonant clusters in three typically developing monolingual toddlers (1 boy, 2 girls) from high SES backgrounds (HSES), who were acquiring Standard Austrian German. They were recorded longitudinally at their homes in Vienna, from 1 year 7 months (1;7) up to 3;0 years. She divided this period into three⁵ developmental phases (phase 1: 1;7–2;0, phase 2: 2;1–2;6, phase 3: 2;7–3;0). All of these data were transcribed and coded by using an adapted German version of CHILDES (cf. MacWhinney 2000). Freiberger analysed 180 minutes per child and phase and investigated all correctly and incorrectly produced consonant clusters in the spontaneous speech of these mother-child interactions in word-initial, -medial and -final position.

The results show, as expected, that all children make significant progress from the first to the third phase, and that the children have more difficulty with word-initial clusters, which are all phonotactic in German, than with word-final clusters. This can be attributed to the fact that final elements are perceived best, well known as the *recency effect* (cf. Eysenck & Keane 2000). In this study no significant morpheme boundary effect was found, which reveals that there is no difference between morphonotactic and phonotactic consonant clusters in the early acquisition of German.

In another investigation by Korecky-Kröll et al. (2016) the spontaneous speech of parent-child interactions of 29 typically developing monolingual and Standard Austrian German-acquiring children from different SES backgrounds (HSES vs. lower SES (LSES)) (7 boys and 8 girls of HSES, 8 boys and 6 girls of LSES) of the INPUT project⁶ was analysed. The children were video and audio recorded in everyday situations with their main caretakers in their homes in Vienna at four data points at the

⁵ Except for the boy, whose audio recordings already started at age 1;3, and therefore have an additional fourth phase (phase 0: 1;3–1;6), cf. (Freiberger 2014: 7).

⁶ INPUT project: 'Investigating Parental and Other Caretakers' Utterances to Kindergarten Children' (SSH11-027) funded by the Wiener Wissenschafts-, Forschungs- und Technologiefonds (WWTF Vienna Science and Technology Fund).

mean ages 3;1, 3;4, 4;4 and 4;8. The most interactive 30 minutes per recording were transcribed, coded and analysed, which is equivalent to 58 hours of spontaneous speech material. The correct use of Cst (consonant +st) clusters, in a medial and final position was examined, in correlation to the effects of the data point, SES and morpheme boundary.

The results demonstrated that the children made significant progress from the third to the fourth data point and also showed a significant effect of the socio-economic status, since LSES children showed lower accuracy. Similarly to Freiberger's investigation (see above), there was no significant influence from the morpheme boundary.

The overall results show that there are no differences in first language acquisition of German between morphonotactic and phonotactic consonant clusters, neither in very young (Freiberger 2014) nor in older children (Korecky-Kröll et al. 2016). This is similar to the findings of Kirk and Demuth (2005) for English, which is a still more weakly inflecting language than German, and unlike the results presented in studies of strong inflecting, morphologically richer languages, such as Polish and Lithuanian (cf. Zydorowicz 2007, 2009, 2010; Kamandulytė 2006; Zydorowicz et al. 2015), in which the authors showed some differences in favour of morphonotactic clusters. This difference might be due to the fact that most of the investigated German morphonotactic clusters occurred in inflected word forms. Still, Freiberger (2007: 20) demonstrated that the presence of a morpheme boundary does not render word recognition and production in child speech (CS) more difficult.

There are two open issues which we would like to address. First, whether or not the preference for morphonotactic clusters in certain languages or their morphological subsystems depends on the degree of morphological richness; and second, whether the acquisition of distinct consonant patterns truly correlates with the presence of a morpheme boundary, or whether, instead, the morpheme boundary itself is the important factor, regardless of the existence of a consonant cluster.

3. CONSONANT CLUSTERS IN PROCESSING

3.1. PREVIOUS EXPERIMENTS

To test the Strong Morphonotactic Hypothesis for German in adult and adolescent processing, four experiments were performed, which led to divergent results. A study by Korecky-Kröll et al. (2014) used a visual sequence targeting experiment in which 84 native Standard Aus-

trian German-speaking participants had to detect whether a given stimulus contained either one letter (T) or a sequence of two letters (ST, AN). The experiment was divided into four different tasks: find T (in words containing ST); find T (in a word containing only T, but not ST); find ST; and find AN. In the first two parts participants had to find T a) in a consonant+st (Cst) sequence (e.g. *Obst* ‘fruit’ vs. *lob-st* ‘you praise’) and b) in a consonant+t (Ct) combination (e.g. *Karton* ‘cardboard’ vs. *dank-te* ‘thanked’, *Lift* ‘elevator’ vs. *pack-t* ‘(s/he/it) packs’). In the third task, participants had to detect ST in a word presented visually (e.g. *Stempel* ‘stamp’ vs. *brav-ste* (good-SUP) ‘best’ superlative); and in the fourth, they had to find AN (e.g. *Fasan* ‘pheasant’ vs. *vor-an* ‘ahead’). Half of the stimuli did not contain the respective sequence, whereas the other half was divided into subgroups that contained the sequence in different positions. For example, in the find T (in T) experiment, 96 stimuli did not contain a /t/, whereas 16 stimuli contained a /t/ in the initial position, 16 in a medial position without morpheme boundary, 16 in a medial position with morpheme boundary, 16 in the final position without morpheme boundary, 16 in the final position with morpheme boundary as a default and 16 in the final position with obligatory morpheme boundary (after a diphthong or long vowel).

Besides other factors, the authors reported a significant facilitating impact from the morpheme boundary only in terms of reaction times (RT), but not of accuracy (ACC), which indicates processing on a sublexical level.

Celata et al. (2015) examined the processing of morphonotactic and phonotactic clusters in German in two different experiments. First, they performed a split cluster task, in which 38 adults (29 years and older) and 26 adolescents (11 to 15 years of age), all native speakers of Standard Austrian German, had to create novel diminutives and attenuative forms by inserting the vowel /i/ between two consonants (CC→CiC). They were presented with 14 monosyllabic test items ending in a Cst-cluster, half containing a morphonotactic cluster, half a phonotactic one, and 56 filler words with differing clusters. Thus, they had to transform, for example, a Cst-cluster /nst/ into /nist/ or /nsit/ in phonotactic *Dunst* ‘mist’ (→ **Dunⁱnist* or **Dunⁱsit*) and in morphonotactic *kenn-st* ‘you know’ (→ **kennⁱnist* or **kennⁱsit*). The result showed an overall preference for /ist/ over /sit/ responses and, only within the adult group, high accuracies regardless of the type of cluster. For the group of adolescents, the morphonotactic clusters were significantly easier to split than the phonotactic ones, whereas the adult group only showed a trend in favour of the stimuli containing a

morpheme boundary. This demonstrates that the presence of a morpheme boundary tends to be helpful in connection with a word modifying task.

Second, a fragment monitoring task was conducted with 28 adolescents (aged 12 to 16) and 41 adults (aged 25 to 59), again all native speakers of Standard Austrian German. Participants were visually presented with a string in capital letters in the centre of the screen, while hearing words over headphones. They had to decide as quickly as possible whether the auditorily perceived word contained the string presented on the screen. In this experiment 30 German words, with a Cst-cluster in the mid- or final position, and 75 filler words, containing other clusters, served as stimuli (e.g. the Cst-cluster /nst/ in phonotactic *Kunst* 'art' vs. morphonotactic *kenn-st* 'you know').

The results showed that, overall, adults were significantly more accurate compared to the group of adolescents, which shows again that the acquisition of phonology and morphonology is not completely finished in adolescence. Despite our expectations, the presence of a morpheme boundary had no effect on adult accuracy, although it did have an effect in the latency of the younger group, with phonotactic patterns being detected faster than morphonotactic ones. Also, the adolescents made more errors in morphonotactic items. The authors point to the significant impact of frequency in this case, since high-frequency items were more often not only judged correctly, but also faster than low-frequency ones in the adult group, whereas this frequency difference did not show as much of an effect in adolescents. This points to different processing strategies in such a recognition task across ages.

Since the above experiments focused only on the sublexical level, as either morphemes, parts of morphemes or clusters that contained morphemes were processed, there was a strong need to investigate adult language processing on a higher level of language awareness, namely the lexical level.

3.2. EXPERIMENTS ON LEXICAL ACCESS

In order to investigate the influence of (mor)phonotactics in lexical processing and to see whether morphonotactics facilitates or impedes visual word recognition, various experiments were performed within our research project.

The findings of all new experiments are first summarized and only afterwards are they accurately described. To investigate the processing of morphonotactic and phonotactic consonant clusters in whole word rec-

ognition, we conducted a progressive demasking task (PDT) and four different lexical decision tasks (LDT):

1. Inflection vs. simplex words (LDT 1)
2. Progressive demasking task on inflection vs. simplex words (PDT)
3. Compounds vs. simplex nouns (LDT 2)
4. Derivations vs. simplex nouns (LDT 3)
5. Compounds and derivations vs. simplex nouns (LDT 4)

Previous studies on whole-word processing have demonstrated a higher processing cost for inflected word forms as opposed to monomorphemic words (e.g. Finnish, cf. Laine et al. 1999) or for inflected base forms (e.g. German, cf. Günther 1988). Therefore, the first experiments (LDT 1 and PDT) were created by Freiburger et al. (2015) to test whether native speakers of German show similar tendencies and whether they are sensitive to the presence of a morpheme boundary within a consonant cluster (e.g. /gt/, /bl/, /mt/) when the item is an inflectional form, or whether the morpheme boundary would not delay processing.

Both experiments (LDT 1 and PDT) contained inflected word forms which are non-citation forms. This suggested that it might be problematic to compare a citation form to a non-citation form. Therefore, Korecky-Kröll et al. (2016) performed another lexical decision task (LDT 2) in order to clarify this issue. Instead of comparing the processing of inflectional forms to monomorphemic words, compounds, which are citation forms like monomorphemic words, were used. Compounding is also a morphologically rich domain of German, richer than inflection, which is another issue that needed to be addressed. We hypothesized that compounds would be processed not only more accurately but also much faster than monomorphemic words.

In order to cover all categories of word formation, Sommer-Lolei et al. (2017) also conducted an experiment with derived words compared to monomorphemic words (LDT 3). Derivations, like compounds, are citation forms, but are expected to be harder to process, because compounds are morphosemantically more transparent than comparable derivations.

In our final lexical decision task 4 we combined the two previous experiments (LDT 2 and 3) into one, considering two newly introduced variables, namely familiarity and foreignness (see also 3.7).

3.3. METHODOLOGY

To investigate lexical access, four lexical decision tasks were performed. The experiments (LDT 1, 2 and 3) were designed using the behavioural research software E-Prime 3.0 (Psychology Software Tools, Pittsburgh, PA) and were all carried out on the same Windows laptop (Freiberger et al. 2015; Korecky-Kröll et al. 2016; Sommer-Lolei et al. 2017). LDT 4 was an online experiment, programmed and provided by URL: <https://quest.christiner.at/>. Due to the high number of participants that were all tested in one day, we tested on several Windows computers simultaneously. All of the test items were presented to the participants visually, capitalized in the centre of the screen, following a fixation cross. Participants had to decide as accurately and quickly as possible whether the presented string was an existing German word or not. The relevant keys were marked with a green sticker for an affirmative response, and a red sticker for a negative response. All reaction times measured in LDT 1, 2 and 3 that were below 300 ms or exceeded 2500 ms were excluded from the analysis. For LDT 4 reaction times were measured but considered as not reliable due to the high number of different computers used at the same time and intermittent connectivity issues.

The progressive demasking task (PDT) was used to test word identification. The experiment was designed using the PDT software (Dufau, Stevens & Grainger 2008). The cut-off values in this experiment were < 300 ms and > 3500 ms. Participants had to identify on their computer screen a slowly demasking stimulus and to confirm identification of it as soon as possible by pressing a key. As a result, the word disappeared from the screen and they had to type the previously identified word as quickly as possible. The same Windows laptop was used to conduct the experiment as in LDT 1, 2 and 3.

The choice of stimuli for LDT 4 was established as a consequence of two ratings that revealed the degree of familiarity and foreignness of the test items previously used in LDT 2 and 3. In the first rating of compounds vs. monomorphemic words, participants got a list of 96 items and had to decide whether or not the word on the list was a foreign word, and they had to judge spontaneously how familiar they are with this word. While the foreignness rating was a decision task (Yes or No), the familiarity rating had a range on a scale from 1 (well known) up to 5 (unknown). This was conducted using an interactive PDF (Adobe Acrobat DC). Each rating was either forwarded immediately to the investigator via email or all ratings filled in by hand on a printed form were handed in by the participants.

The second rating of derivations vs. monomorphemic words used an on-line questionnaire, programmed and provided by Markus Christiner on an online platform, URL: <https://quest.christiner.at/>. Similarly to the first rating, participants had to decide on the foreignness and familiarity of 96 stimulus words that were presented one after the other, whenever the participant clicked on the *Weiter* ‘next/go on’ button. It was not possible to measure reaction times.

3.4. MATERIALS

In each of the tasks the experimental items were 96 German words and 96 German-based non-words (one letter of a German word was changed in the monomorphemic words, two letters were changed in the compound and derivation-based items, i.e. one consonant or vowel in each of the two morphological parts), with the exception of LDT 4, in which the stimuli were 96 German words and 32 German-based non-words, divided into four conditions, as presented in Table 1:

Table 1. Conditions of the test stimuli

Condition		Explanation
1	M+P+	containing a consonant cluster that crosses the morpheme boundary
2	M+P–	containing a morpheme boundary, but no consonant cluster
3	M–P+	monomorphemic word containing a consonant cluster
4	M–P–	monomorphemic word without a consonant cluster

This results in 24 words and 24 non-words per condition. Half of the items contained a morpheme boundary, while the other half did not, which is exactly the same as the items containing or not containing a consonant cluster. In LDT 1 and the PDT (Freiberger et al. 2015), stimulus words contained only biconsonantal clusters (e.g. /gr/, /br/), whereas in LDT 2 (Korecky-Kröll et al. 2016), LDT 3 (Sommer-Lolei et al. 2017) and LDT 4, bi- and triconsonantal clusters occurred (e.g. /rtn/, /lst/). The position of the consonant clusters was either in the final (LDT 1) or in a medial position (LDT 2, 3 and 4). For every morphonotactic consonant cluster there existed a phonotactic match (e.g. LDT 2 on compounds: (M+P+) *Haus+tier* ‘domestic animal’ vs. (M–P+) *Kastanie* ‘chestnut’). Therefore, we also matched conditions 2 and 4 (e.g. LDT 3 on derivations: (M+P–) *Zeig-er* ‘pointer’ vs. (M–P–) *Lager* ‘storage’). Examples of stimuli for each experiment are listed in Table 2; for a summarizing

overview of the tasks, see Tables 3 and 4. All of the items were balanced for word length, syllables and average word frequency (taken as the number of occurrences from the CELEX, the Austrian Media Corpus (AMC⁷) and also the *Leipzig Deutscher Wortschatz Online* databases).

Table 2. Examples for German words used in the experiments per condition

Task	LDT 1 & PDT (Inflection)	LDT 2 (Compounding)	LDT 3 (Derivation)
		LDT 4 (Compounding and Derivation)	
Cond. 1 (M+P+)	<i>wag-te</i> ‘dared’	<i>Haus+tier</i> ‘domestic animal’	<i>Eitel-keit</i> ‘vanity’
triconsonantal clusters	-	<i>Hals+tuch</i> ‘scarf’	<i>Gärt-ner</i> ‘gardener’
Cond. 2 (M+P-)	<i>heb-en</i> ‘lift’	<i>Tee+tasse</i> ‘teacup’	<i>Zeig-er</i> ‘pointer’
Cond. 3 (M-P+)	<i>Zimt</i> ‘cinnamon’	<i>Kastanie</i> ‘chestnut’	<i>Balsam</i> ‘balm’
triconsonantal clusters	-	<i>Holster</i> ‘holster’	<i>Partner</i> ‘partner’
Cond. 4 (M-P-)	<i>Mücke</i> ‘mosquito’	<i>Rakete</i> ‘rocket’	<i>Lager</i> ‘storage’

3.5. PARTICIPANTS

All the participants were adult monolingual native speakers of Standard Austrian German. None of them reported visual or neurological impairments or a history of language disorders.

In LDT 1, in which processing of inflectional forms was compared to monomorphemic word processing, 46 adults (aged 19 to 35) participated.

In the progressive demasking task, in which the same inflectional forms and monomorphemic words taken from the previously conducted LDT 1 had to be identified, 45 adults (aged 19 to 31) participated, likewise in LDT 2, in which the processing of monomorphemic words was compared to the processing of compounds and in LDT 3, where the processing of derivations compared to monomorphemic words was investigated.

The first rating of foreignness and familiarity with regard to the list of compounds and monomorphemic words was conducted with 130 adult participants (aged 18 to 51); the second rating of the stimulus word list

⁷ The Austrian Media Corpus of the Austrian Academy of Sciences, based on APA (Austrian Press Agency) data, consists of over 10 billion word tokens. URL: <https://www.oeaw.ac.at/acdh/tools/amc-austria-media-corpus/> [20.03.2019].

of derivations and monomorphemic words was performed by 102 adults (aged 20 to 59). Both ratings were used for stimulus word selection in LDT 4.

In LDT 4, as our most recently performed experiment, in which 84 adults (aged 18 to 36) participated, we united the previous two experiments LDT 2 and 3 in order to investigate the processing of compounds and derivations compared to monomorphemic words, in consideration of the familiarity and foreignness ratings of the stimulus words, where we selected in equal parts very familiar, familiar, very unfamiliar, very foreign, foreign and non-foreign stimulus words (compounds, derivations and monomorphemic nouns).

For a summary of all the performed tasks, ratings and participants, see Tables 3, 4 and 5:

Table 3. Overview of the visual word recognition tasks on inflection

Task	LDT 1	PDT
	Inflection	Inflection
No. participants (age)	46 (19–35 yrs.)	45 (19–31 yrs.)
Method	E-Prime 3.0	PDT Software
Computer	Win. Laptop	Win. Laptop
RTs measured	Yes	Yes
Cut off values ms	< 300 > 2500	< 300 > 3500
No. stimulus words	96	96
No. stimulus non-words	96	96
Conditions (Tables 1, 2)	1–4	1–4

Table 4. Overview of the lexical decision tasks on compounding and derivation

Task	LDT 2	LDT 3	LDT 4
	Compounding	Derivation	Comp. & Derivation
No. participants (age)	45 (19–31 yrs.)	45 (19–31 yrs.)	84 (18–51 yrs.)
Method	E-Prime 3.0	E-Prime 3.0	Online
Computer	Win. Laptop	Win. Laptop	Various Computers
RTs measured	Yes	Yes	Yes
Cut off values ms	< 300 > 2500	< 300 > 2500	RT not reliable
No. stimulus words	96	96	96
No. stimulus non-words	96	96	32
Conditions (Tables 1, 2)	1–4	1–4	1–4

Table 5. Overview of the familiarity and foreignness ratings

	Rating 1	Rating 2
	Comp. and simplex words	Deriv. and simplex words
No. stimuli	96	96
No. participants (age)	130 (18–51 yrs.)	102 (20–59 yrs.)
Method	interactive PDF (Adobe Acrobat DC)	Online questionnaire
Familiarity (scalar)	1 (well known) to 5 (unknown)	
Foreignness (nominal)	Yes or No	

3.6. RESULTS OF THE PROCESSING EXPERIMENTS

In the first whole-word recognition tasks, conducted by Freiberger et al. (2015), divergent results were found. Regarding the LDT 1 and the PDT on inflection, they found that in both experiments words with a morpheme boundary were significantly more difficult to process than all the other categories. In particular, the category M+P+, which are strings that contain a morpheme boundary and a consonant cluster, showed the highest latency, and in the lexical decision task also the lowest accuracy. This is in accordance with processing models which assume that affixed words are decomposed into base form and affix, which leads to higher processing costs. They did not find this accuracy result in the PDT; instead words without a morpheme boundary and with a consonant cluster (M–P+) were processed more accurately. The longer reaction times for the M+P+ items can be explained by the fact that these strings were all inflectional forms. Therefore, Freiberger and colleagues concluded that it is problematic to compare a non-citation form with a citation form, as already mentioned above, but also, this may be due to the fact that German is only a weakly inflecting language, in which inflectional morphology is not important enough to facilitate lexical processing. In the strongly inflecting language Polish, Zygorowicz and Dziubalska-Kolaczyk (2017) found that the morpheme boundary helped processing. The results furthermore show that it is not the cluster that renders word recognition more difficult, but rather the morpheme boundary combined with the cluster. In this case the Strong Morphonotactic Hypothesis could not be confirmed for German, although there had been some evidence for it on the sublexical level in previous experiments (see 3.1).

In order to verify these findings and to test the hypothesis concerning the impact of citation forms, Korecky-Kröll et al. (2016) conducted the

second experiment, LDT 2, on compounding. Since inflected word forms were included in the first experiments (Freiberger et al. 2015, see above), we wanted to see whether words that are citation forms, like monomorphemic words, and that derive from a morphologically rich domain of German, much richer than inflection, would lead the participants to a different behaviour. The results for accuracy showed that compounds with morphonotactic clusters (M+P+ items, with morpheme boundary and consonant cluster), but also M+P– items (compounds without a consonant cluster) show significantly higher accuracy than either type of monomorphemic words. This diverges from the results of the previous lexical decision experiments on inflection, and therefore supports the Strong Morphonotactic Hypothesis. The results for latency showed no significant difference, but a trend in favour of M+P+ compounds (with morpheme boundary and with consonant cluster).

These results have demonstrated that the decomposition of compounds does not slow down processing but is, rather, automatic, which supports Libben's (2014) principle of maximum opportunity.

Korecky-Kröll et al. (2016) therefore concluded that the facilitation process in the acquisition and processing of morphonotactic clusters only seems to apply in a language or linguistic domain that is morphologically rich, and it was suggested that the Strong Morphonotactic Hypothesis be modified accordingly (also in Sommer-Lolei et al. 2017). Thus, the interaction with morphology appears to facilitate processing where it "is worth it".

The third lexical decision experiment on derivational morphology (LDT 3) was performed by Sommer-Lolei et al. (2017) in order to support our theoretical claim that the morphological richness of a certain area facilitates processing, i.e. by also investigating the derivational domain.

The results of the LDT 3 demonstrated that M+P– items in particular (derivations containing a morpheme boundary, but no consonant cluster), but also M+P+ items (derivations containing a morpheme boundary and a consonant cluster), yield a significantly higher accuracy and are processed significantly faster than both types of monomorphemic words. Derived nouns (derived via productive word-formation rules) were processed more accurately than simplex nouns. Unlike the previous experiment on compounding (Korecky-Kröll et al. 2016, see above), these results do not support the Strong Morphonotactic Hypothesis directly but only indirectly, insofar as we found a positive effect on processing whenever a morpheme boundary is present.

To demonstrate differences in the processing of morphonotactic and phonotactic consonant clusters in compounds, derivations and monomorphemic words (LDT 4), a repeated measures ANOVA was performed on the mean values of the correct responses. The results show, with a Greenhouse-Geisser correction, that words containing a morpheme boundary were processed significantly differently $F(2.48, 195.73) = 30.76, p < 0.01$, regardless of whether the string contained a consonant cluster or not. Condition 1 (M+P+ Mean = 0.85) was significantly different from conditions 3 (M-P+ Mean = 0.79) and 4 (M-P- Mean = 0.79) but not from condition 2 (M+P- Mean = 0.84). M+P+ and M+P- items were significantly different from both categories without a morpheme boundary.

3.7. RESULTS OF THE FAMILIARITY AND FOREIGNNESS RATINGS

In our lexical decision tasks on compounds (LDT 2) and derivations (LDT 3) the high number of foreign words within the group of monomorphemic words (e.g. *Taifun* ‘typhoon’, *Baklava* ‘baklava’) that were used within the experiments still seemed problematic to us as a possible confounding factor. Use of these items was due to the necessity of matching compounds and derivations to monomorphemic words in frequency and word length.

Therefore, we had 130 German native speakers rate all our stimulus words for the compound experiment in terms of the degree of familiarity and foreignness, which revealed that the four categories of stimuli differed significantly in their perceived degree of foreignness (see Figure 1), whereas in the familiarity rating only monomorphemic words without consonant clusters (M-P-) were rated significantly less familiar than all other categories (see Figure 2):

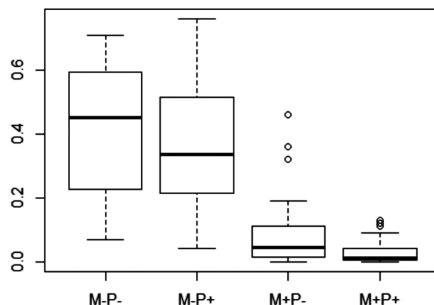


Figure 1. Degree of foreignness in the four categories
(Rating of stimulus words for LDT 2)

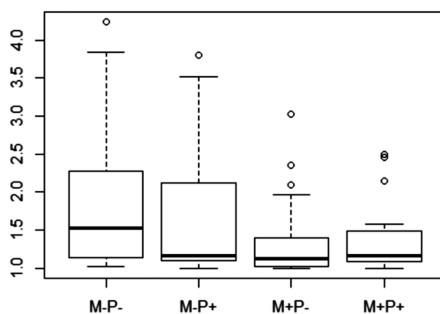


Figure 2. Degree of familiarity in the four categories
(Rating of stimulus words for LDT 2)

The results for compounds and monomorphemic words show that foreignness and, especially, unfamiliarity reduce accuracy and delay the speed of processing significantly.

Although familiarity and foreignness were less likely to constitute intervening variables for derivations than for compounds, we nevertheless had the 96 stimulus words rated for this experiment by 102 native speakers of German, which revealed a significant difference between the categories M– and M+ regarding the degree of foreignness (see Figure 3). In the familiarity rating we found no significant difference between the four categories (see Figure 4).

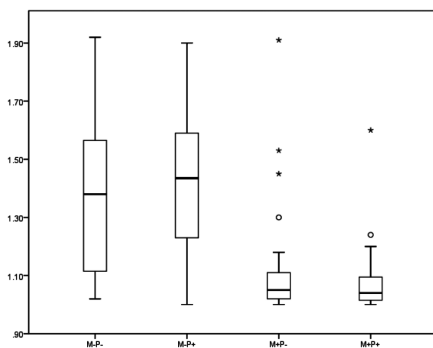


Figure 3. Degree of foreignness in the four categories
(Rating of stimulus words for LDT 3)

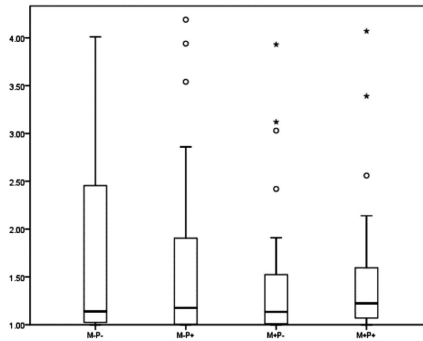


Figure 4. Degree of familiarity in the four categories
(Rating of stimulus words for LDT 3)

4. STATISTICAL ANALYSES

4.1. IMPACT OF FREQUENCY, FAMILIARITY AND FOREIGNNESS ON ACCURACY

As mentioned above, we hypothesized that familiar words, ranked in advance by native speakers of Standard Austrian German (see also 3.4), would be processed significantly more accurately than unfamiliar words and second, that stimulus words judged as foreign would result in significantly lower accuracy than all of the other words.

To demonstrate the effects of frequency, familiarity and foreignness in adult language processing we analysed their impact in terms of accuracy of words (non-words were excluded) in LDT 2 (compounds vs. simplex nouns), LDT 3 (derivations vs. simplex nouns) and LDT 4 (compounds and derivations vs. simplex nouns).

As for LDT 2 (Korecky-Kröll et al. 2016), statistical analyses of the accuracy of words reveal that words with a high AMC token frequency are significantly more likely to be judged correctly and that high-frequency words containing a morpheme boundary, especially M+P+ items, are processed significantly more accurately than words without one. In terms of familiarity and foreignness, we found that stimulus words that are either unfamiliar and/or foreign have significantly less accurate results than familiar and non-foreign words. In addition, there is no difference in this respect in the processing of morphonotactic and phonotactic consonant clusters across the four categories.

In our LDT 3 on derivations compared to monomorphemic nouns (Sommer-Lolei et al. 2017), words containing a morpheme boundary have significantly more accurate results compared to monomorphemic

words, regardless of the absence or presence of a consonant cluster. Also, we found that words without a consonant cluster and without a morpheme boundary (M–P–) are processed significantly less accurately than M–P+, which demonstrates a processing strategy of preferring a phonotactic consonant cluster whenever no morpheme boundary is present. In other words, the presence of a morpheme boundary leads to significantly higher results than the presence of a cluster. This indicates the relevance of morpheme boundaries.

Similar to our finding in LDT 2, we found, with regard to familiarity and foreignness, that stimulus words that are either unfamiliar or foreign or both have significantly less accurate results than familiar/non-foreign words. In the case of familiarity of items, there is no difference in the processing of morphonotactic and phonotactic consonant clusters. However, when items are foreign, we found that words with a phonotactic consonant cluster (M–P+) are processed significantly more accurately compared to all other categories.

This appears to mean that (rather) foreign words of limited length are expected to be monomorphemic words, and this respects the fact that more simplex words are loaned than affixed words, in contrast to loaned English compounds.

By merging the previously conducted two experiments into one new experiment with respect to the degree of familiarity and of foreignness of the stimulus words, we found, with regard to the impact of token frequency, that words containing a morpheme boundary were processed with significantly greater accuracy compared to monomorphemic words, with M+P– items scoring highest. The processing of unfamiliar or foreign words in LDT 4 shows that these items are processed significantly less accurately, as in the previously conducted LDT 2 and 3. For familiarity we found no significant difference between the four categories. Foreign words containing a morpheme boundary have significantly less accurate results than words without it.

Statistical analyses of accuracy undertaken by means of a repeated measures ANOVA reveal differences in the processing of the three categories (compounds, derivations, simplex nouns). The results show that each of the three categories led to highly significant differences from each other: $F(2,158) = 35.29$, $p < 0.01$. Independently of whether the item was a word or a non-word, compounds were processed with significantly more accuracy than simplex nouns, whereas derived words resulted in an intermediary position, significantly different from both compounds and monomorphemic nouns (see Figure 5).

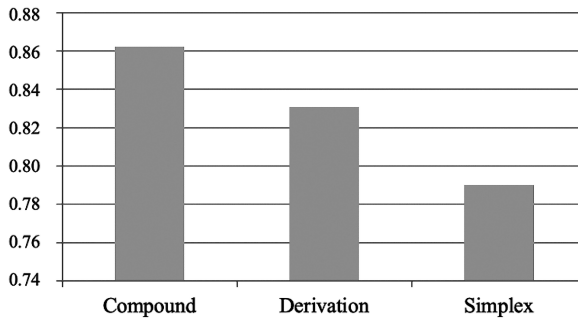


Figure 5. Mean values of accuracy in processing in compounds, derivations and simplex words

When analysing our data (LDT 2, 3 and 4) with regard to familiarity by using general linear mixed-effects models (Bates et al. 2015), we found that very unfamiliar words are processed with significantly less accuracy in all three experiments, but that there were no significant differences with regard to the presence vs. absence of a morpheme boundary or consonant cluster or both. Familiarity is shown to be a highly influential factor when it comes to compounds (LDT 2 and 4), whereas in LDT 3 (derivations vs. simplex nouns), familiarity is an intervening variable to a lesser extent (see Table 6).

It is a novel finding, as first presented by Sommer-Lolei et al. (2017), that familiarity is a more important variable in compounds than foreignness, which itself is more important than token frequency. The results for LDT 2 show that foreignness is much closer to frequency than to familiarity. Therefore, we can conclude that although all three variables are significant in respect of processing, familiarity is the most important factor when dealing with compounds, which is also a warning against relying excessively on frequency. Instead, other variables, in particular familiarity, should be considered as well.

Thus, results point to the fact that it is important whether a given string is a citation form or not, and, additionally, whether the item contains a morpheme boundary is rather important, although we only found effects of morphonotactic consonant clusters in LDT 2 and 4, which demonstrates the strong impact of compounds.

Overall, the presence of a morpheme boundary facilitates word recognition and processing except for unfamiliar and foreign words, regardless of whether there is a consonant cluster or not.

Table 6. Hierarchy of influencing factors on the accuracy of German stimulus words

Accuracy of words in:			
LDT 2 (Comp. vs. Simplex)	Familiarity >	<i>Foreignness</i> >	Frequency
<i>z values and significance levels</i> ⁸	-14.007***	-4.935***	3.781***
<i>AIC values</i> ⁹	1906.541	1996.92	2006.647
LDT 3 (Deriv. vs. Simplex)	Frequency >	Familiarity >	<i>Foreignness</i>
<i>z values and significance levels</i>	12.631***	-14.017***	-5.609***
<i>AIC values</i>	1489.297	1494.002	1576.088
LDT 4 (Comp./Deriv. vs. Simp.)	Familiarity >	Frequency >	<i>Foreignness</i>
<i>z values and significance levels</i>	-12.573***	8.361***	-5.807***
<i>AIC values</i>	3493.344	3529.927	3559.36

4.2. INFLUENCE OF FREQUENCY, FAMILIARITY AND FOREIGNNESS ON LATENCY

Reaction times were measured for LDT 2 and 3, but as already mentioned above, this was impossible for LDT 4. The results demonstrate in both experiments that frequency has an impact in the sense that words with a high token frequency in the AMC corpus are processed significantly faster, regardless of whether the word contains a morpheme boundary and/or a consonant cluster or not. Thus, the positive influence of a morpheme boundary on accuracy has no correspondence in latency. Interestingly, the interaction of morphology with phonological processing appears to increase accuracy, because accuracy is monitored on one additional level, whereas it neither slows down nor accelerates processing significantly.

In terms of familiarity, we find that unknown or very unfamiliar words were processed significantly slower in both experiments. In LDT 2 (com-

⁸ The following significance levels were selected: * 0.05, ** 0.01, *** 0.001. Please note that the negative *z* values for the foreignness and familiarity rating are due to the coding. For foreignness, this is more intuitive: if a word was rated as being not a foreign word, this was coded as 1, whereas 2 indicated that it was rated as a foreign word. Therefore, as expected, the accuracy of the participants is higher if the word is less foreign. However, the familiarity rating may appear somewhat counterintuitive as it was, instead, an unfamiliarity rating, ranging from 1 (well known or familiar) to 5 (unknown or unfamiliar). This leads to the negative *z* values: the participants' accuracy is higher if a word is less unfamiliar (i.e. more familiar).

⁹ AIC refers to the Akaike Information Criterion (see e.g. Levshina 2015: 149), which was used as the primary criterion for model selection: the smaller the AIC value, the better the fit of the respective model.

pounds vs. simplex nouns), the analysis of reaction times shows that words containing a morpheme boundary but no consonant cluster (M+P–) delay processing significantly, followed by words with a morpheme boundary and cluster (M+P+), which show a weaker effect on latency. In LDT 3 (derivations), we did not find significant differences of this type.

Regarding the degree of foreignness, the analysis reveals that highly foreign words are processed significantly slower in both experiments which is also the case for stimulus words containing a morpheme boundary (with or without consonant cluster). Analysis of LDT 2 (compounding) shows that words with a morpheme boundary that also contain a consonant cluster (M+P+) delay processing with high significance, followed by words with a morpheme boundary and without a consonant cluster (M+P–), which tend to be processed slightly faster. Interestingly we find the opposite picture when analysing data from our LDT 3, which means that words with a morpheme boundary but without a consonant cluster (M+P–) are processed significantly more slowly than the M+P+ items. This points to the fact that the presence of a morphonotactic consonant cluster delays processing in foreign compounds but only shows a weak effect on the latency of foreign derivatives.

As summarized in Table 7, we conclude that with regard to the latency of compounding, familiarity is the major influencing factor, whereas it is frequency that plays a highly important role when processing derivations.

Table 7. Hierarchy of influencing factors on the latency of German stimulus words

Latency of words in:			
LDT 2 (Comp. vs. Simplex)	Familiarity >	<i>Foreignness</i> >	Frequency
<i>z values and significance levels</i>	8.577***	4.669***	-4.980***
<i>AIC values</i>	-5732.506	-5701.464	-5700.359
LDT 3 (Deriv. vs. Simplex)	Frequency >	Familiarity >	<i>Foreignness</i>
<i>z values and significance levels</i>	-12.340***	8.370***	6.313***
<i>AIC values</i>	-6361.651	-6324.792	-6308.46

Morpheme boundaries tended to be helpful on the sublexical level, as found by Celata et al. (2015) in the split cluster task, where frequency also had an important impact (see 3.1). By contrast, our results on lexical processing in terms of latency show significant delays in the presence of morpheme boundaries in unfamiliar and/or foreign words, whereas morpheme boundaries were helpful in familiar and non-foreign words. Frequency was always helpful, but often much less so than familiarity.

5. CONCLUSION

As for German, no effect of the morphonotactic character of consonant clusters is shown in inflection. Therefore, the Strong Morphonotactic Hypothesis is not supported for German inflection, neither in first language acquisition nor in adult or adolescent language processing.

The Strong Morphonotactic Hypothesis could only be supported for German compounding, where the strongest facilitating effect was found for morpheme boundaries with consonant clusters. However, in derivatives too, positive effects of morpheme boundaries (with and without consonant clusters) on processing were found. Nevertheless, when compounds, derivatives and monomorphemic words were directly compared within the same participants, compounds showed significantly higher levels of accuracy than derivatives. This points to the second compound constituent being more readily identifiable, due to its coexistence as an autonomous lexical element, compared to the harder process of retrieving suffixes (inflectional or derivational suffixes). In processing, this is a consequence of the process of chunking elements (here phonemes and graphemes). Apparently morphological chunking is one of the normal processing strategies. Therefore, it is desirable to conduct further experiments in which morpheme and syllable chunking can be compared.

Words are processed faster and significantly more accurately, the more familiar a stimulus word is (particularly in compounding) and, to a lesser extent, the more frequent it is (particularly in derivations). This greater effect of familiarity can be linked to Libben's (2014) principle of opportunity: in compounds, the familiarity of both the whole compound and of the word families of its constituents facilitates processing, whereas the familiarity of the more abstract, i.e. much less morphosemantically descriptive suffixes must have a much smaller influence. As a consequence, the frequency and productivity of suffixes has a relatively greater importance.

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