Representation of German binomials: Evidence from speech production

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Abstract

Binomials (e.g., German Ebbe und Flut; 'ebb and flow') are a common phenomenon of many languages, but little is known about how they are stored, produced and processed. We tested the production of German nominal binomials and compared their onset latency to the onset latency of forms in which one part of the binomial was replaced by an alternative constituent that was phonologically similar to the original (e.g., Brut as an alternative to Flut). Studies on multi-word phrases and idioms suggest that such frequently occurring expressions are accessed faster and produced with shorter duration than infrequent forms, suggesting that they are accessed as a single unit, rather than word-by-word. We hypothesized single storage for frequent binomials and expected shorter onset latencies and constituent durations for original binomial forms than for alternatives. This is what our results show. They hence lend support that advocate single representations for frequent constructions.

Keywords: German, binomial, onset latency, production, constituent duration, association strength, lexical frequency

1. Introduction

Binomials represent a linguistic phenomenon that is present in many languages of the world (e.g., Khatibzadeh & Sameri, 2013; Malkiel, 1959). They are part of everyday language and occur for example in book or film titles, poems and product names and are applied by the advertising industry in order to arouse interest (H.-G. Müller, 2009). But despite the cross-linguistic pervasiveness, most of the previous studies have focused on English binomials (e.g., Cooper & Ross, 1975; Pinker & Birdsong, 1979). For German, the first extensive work, which listed up to 1300 binomials, has only been published in 2009 by H.-G. Müller (2009). Furthermore, the main focus of previous studies was laid on the factors that determine the order of the constituents of a binomial (e.g., Cooper & Ross, 1975, Malkiel, 1959; G. Müller, 1997; Lenz, 2002). On the other hand, we still know very little about how binomials are stored, processed and produced by language users. In the current paper we aim at filling this gap by presenting two production experiments that investigated the mental representation of German binomials (e.g., *Ebbe und Flut, 'ebb and flow'*).

Recent studies on multi-word phrases and idioms suggest that frequently occurring idioms and phrases are stored and accessed as one unit (e.g., Sprenger, Levelt, & Kempen, 2006; Janssen & Barber, 2012). Furthermore these analyses have shown that such high-frequent multi-word units are easier to access leading to shorter onset latencies and constituent durations (e.g., Bybee, 2010; Fenk-Oczlon, 2001; Janssen & Barber, 2012; Tabossi, 2009). Due to the frequent occurrence of binomials, we hypothesize that binomials are also stored and accessed as one entity in comparison to non-binomial coordinations that are structurally similar but do not frequently occur together. To test this hypothesis, we investigated whether common German nominal binomials (e.g., *Ebbe und Flut, 'ebb and flow'*) are initiated earlier and with shorter constituent durations than alternative forms in which one of the constituents is replaced by an alternative phrase (e.g., *Brut (brood) as an alternative to Flut (flow)*).

Since more strongly associated binomials may form stronger exemplars and therefore affect onset latencies and constituent durations, we collected association strength measures, which have been argued to be a viable indication of how frequently the constituents co-occur in daily language use (e.g., Haskins, Yonelinas, Quamme, & Ranganath, 2008; Jenkins & Russell, 1952; Tanaka-Ishii, & Terada, 2011). We predict that more strongly associated binomials are affected more by replacing a constituent than binomials with a weaker association.

2. Experiment 1

In Experiment 1, the second constituents of the original binomials were replaced by words that were phonologically similar but that do not occur frequently with the first constituent. This allowed us to compare the latency for initiating the producing of the two constituents in the original and the alternative form with an identical first constituent across conditions (e.g., *Ebbe und Flut* vs. *Ebbe und Brut*). Furthermore, the duration of the first constituent was compared across conditions.

2.1. Methods

2.1.1. Materials

The original binomials were selected on the basis of a web based association experiment with 35 native speakers of German (17 female, average age 25 years, SD = 2.5). We presented the first constituent of 33 well described binomials that frequently occur in German (taken from Müller, 2009 and Hofmeister 2001, 2010) followed by the conjunction *and* (e.g., *Ebbe und…;* E: *ebb and…*) and asked participants to indicate the first word that came to their mind. From these 33 binomials we selected the 10 items with the highest association strength (on average 94%, SD = 4.3) and the 10 items with the lowest association strength (on average 34%, SD = 6.6). Afterwards the second constituent of the originals was replaced by a phonologically similar noun. The replacement had the same syllable number and stress pattern, a similar phonotactic structure as the original constituent of the binomial (e.g., *Flut* vs *Brut*; see Table 1 in Appendix) and was matched to the original second constituent in lexical frequency according to dlexDB (Geyken, Hanneforth, & Kliegl, 2012). The original second constituents had 120 occurrences per million (o.p.m), the replacements 53 o.p.m. This difference was not significant ($t(19) = 1.3$, $p < 0.2$).

Apart from these 20 experimental nominal constructions, we selected six practice coordinations with proper names (e.g., *Andreas and Pia*).

2.1.2. Participants

Twelve monolingual German speakers (10 female) participated voluntarily (average: 25 years, SD: 3.6); they were unaware of the purpose of the experiment. None of them had taken part in the association experiment.

2.1.3. Procedure

The experimental list contained all original binomial and alternative coordinations (within-subject design). The list started with the six practice trials. The order of the other trials was pseudo-randomized with the constraint that the two versions of a given binomial (its original and alternative) were separated by at least 5 other trials. For one half of the binomials, the original was presented first, for the other half, the alternative was presented first.

Participants were seated in a soundproof cabin wearing headphones with an integrated microphone, which was used to record their productions during the session. In order to avoid read speech, we first presented the second part of the binomial, followed by the first part. Participants had the task to assemble the intended form in the reverse (and hence correct) order. Each trial started with a fixation cross, which appeared at the centre of the screen for 250ms. After a pause of 2s (showing a blank screen), the second constituent of the binomial (e.g., *Flut*) or the replacement (e.g., *Brut*) was presented for 350ms in black Arial 42font on white background at the centre of the screen. After another pause of 2s, the first constituent together with an ampersand appeared (e.g., *Ebbe &*) in the same font centred on screen. Together with the visual onset of the second constituent, a beep of 10ms duration was played to the left channel of an M-Audio Microtrack II recorder. Participants were instructed to remember the second part of the binomial and to produce the binomial in the correct order as quickly as possible. Their productions were recorded on the right channel of the recorder (44.1kHz, 16Bit). The ampersand was used to unambiguously mark the first constituent of the nominal construction.

2.2. Results

The recordings were manually annotated at the lexical word level, using broadband spectrograms and standard segmentation criteria (Turk, Nakai & Suguhara 2006). In particular, we manually measured participants' onset latencies relative to the onset of the visual presentation as well as the duration of the first constituent. Onset latencies and the duration of the first constituent of the productions were statistically analysed using linear mixed effects regression models with *coordination type* (original binomial vs. alternative) and *association strength* of the original binomial (strong vs. weak) as fixed factors and *participants* and *items*, as crossed random factors allowing for random adjustments of intercepts and slopes (Barr, Levy, Scheepers, & Tily, 2013). We additionally included *trial* number and *attempt* (first or second encounter of a coordination) as control predictors. *P*-values were calculated by comparing a model with a given factor (or interaction) to a model that lacked that factor (or interaction), all else being equal (using the anova-function in R). Results for onset latencies showed a significant main effect of *coordination type* (ß = -0.035, SE = 0.009, $p < 0.005$), but no effect of *association strength* and no interaction (both *p*-values > 0.2). Similarly, *attempt* and *trial number* did not have an effect (all *p*-values > 0.3). Original binomials were initiated on average 35ms earlier than the alternative forms (420ms vs. 385ms, see left-hand bars of Figure 1).

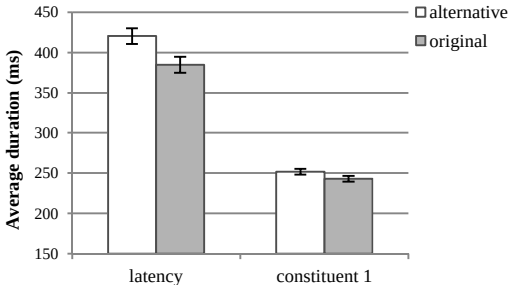

Figure 1: *Average onset latency and duration of the first constituent, split by coordination type (alternative vs. original), as calculated by the statistical model. Whiskers show standard errors.*

For the duration of the first constituent, the model showed a significant effect of *coordination type* as well (ß = -0.009, SE = 0.004, $p = 0.02$). The first constituents of original binomials were on average 9ms shorter than the same constituents in the alternative constructions (252ms vs. 243ms, see Figure 1).

In order to exclude the alternative possibility that the results are caused by semantic priming from the second constituent of the binomial (which was shown on screen first) on the first constituent, we additionally collected the backwards association strength, i.e. the association strength between the second constituent of the binomial (original constituent vs. replacement) and the original first constituent. We tested a different set of 96 participants in a web-based association experiment (58 female, average 26 years, SD = 2.8). Participants were visually presented with the second constituent (original or replaced, manipulated within-subjects), followed by the conjunction *and* (e.g., *Flut und …)* and had to type in the first word that came to their mind. We calculated the backwards association strength between the presented second constituent (e.g., *Flut* or *Brut*) and the original first constituent (e.g., *Ebbe*). The average backward association strength ranged between 0% and 92%. It was on average 44% for originals and 0% for alternatives ($t(19) = 2.7$, $p < 0.05$). We then selected the 10 binomials, for which the original had the lowest backwards association strengths (on average 25,4%, SD = 25.3) and their alternatives and ran the model again. Importantly, we also see an effect of coordination type on onset latencies and on the duration of the first constituent for this subset (ß = -0.03, SE = 0.001, $p < 0.05$ and ß = -0.02, SE = 0.007, $p < 0.005$, respectively). The effect sizes are comparable to those of the complete data set.

2.3. Discussion

The results of the first experiment show a significant effect of coordination type on the onset latency of original binomials and on the duration of the first constituent. This finding is in line with our hypothesis that binomials are stored as one entity in the mental lexicon and are therefore accessed faster and produced with a shorter duration. Furthermore our results suggest that these findings also hold for those binomials that have a weak associative connection. Note that our analyses did not show an effect of attempt (the first or second encounter of a coordination), which suggest that the current within-subjects design is a useful method to study the representation of

binomial constructions. In order to corroborate our findings we tested whether the second constituents also have shorter durations in original binomials compared to alternatives.

3. Experiment 2

Experiment 2 investigated whether *coordination type* also effects the duration of the second constituent in a binomial. Therefore we created alternative coordinations in which the first constituent was replaced by an alternative constituent.

3.1. Methods

3.1.1. Materials

For each of the 20 binomials of Experiment 1, we created 20 novel alternatives by replacing the first constituent (e.g., ***Ebbe** und Flut* had the alternative: ***Treppe** und Flut*). As in Experiment 1, the original constituents and the replacements had the same syllable structure, stress pattern and a similar phonotactic form and did not differ in lexical frequency (189 o.p.m for originals compared to 115 o.p.m for alternatives, a difference that was no significant: $t(19) = 1.7$, $p < 0.3$).

3.1.2. Participants

Twelve monolingual German native speakers (11 female) participated voluntarily (average: 24 years, SD = 2.8). None of them took part in any of the experiments reported above; they were not informed on the purpose of the experiment.

3.1.3. Procedure

The procedure, the experimental lists, and the recording setting were identical to Experiment 1.

3.2. Results

The recordings were manually coded at the lexical word level using the same criteria as in Experiment 1. The duration of the second constituent was analysed using a linear mixed effects regression model with *coordination type* (original binomial vs. alternative) as fixed factor and *participants* and *items* as crossed random factors allowing for random adjustments of intercepts and slopes (Barr et al., 2013). Results showed a significant main effect of *coordination type* (ß = -0.016, SE = 0.005, p = 0.0004).

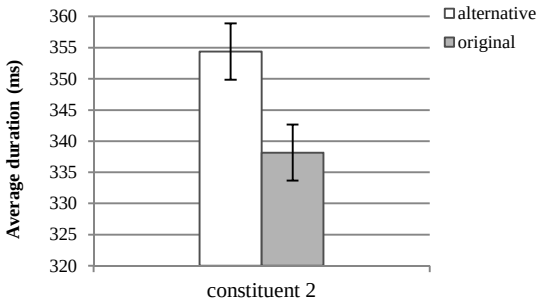

Figure 2: *Average duration of the second constituent split by coordination type (alternative vs. original), based on the statistical model. Whiskers show standard errors.*

The second constituent of the original binomials was on average 16ms shorter than the second constituent in alternatives (354ms vs. 338ms, see Figure 2). Similarly to Experiment 1, *attempt* (first or second presentation of a binomial) and *trial number* did not have significant effects on the duration of the second constituent (both *p*-values > 0.1).

3.3. Discussion

Experiment 2 showed that participants produced original binomials with a shorter second constituent compared to coordinations in which the first constituent was replaced by an alternative noun. The current findings hence corroborate the findings reported in Experiment 1 and lend further support to the interpretation that common binomials are stored and accessed as one unit, which leads to shorter durations in comparison to non-binomial coordinations.

4. General Discussion

We presented two production experiments that probed the representation of binomials by means of onset latencies and constituent durations. We showed shorter onset latencies for the initiations of German binomials, as compared to coordinations in which one of the constituents was replaced by a structurally similar noun. Furthermore, the two constituents of an original binomial were produced with shorter durations compared to the alternative coordinations. Together, these results are in line with usage-based accounts (e.g., Bybee, 2010; Tomasello, 2003) and certain other proposals regarding the representation of frequent multi-word expressions (e.g., Sprenger et al., 2006), which predict shorter onset latencies and constituent durations for high frequency words and constructions (e.g., Fenk-Oczlon, 2001; Tabossi et al., 2009; Janssen & Barber, 2012). Note that our results cannot be explained by the lexical frequencies of the individual constituents of the binomial alone, but are the result of the *coordination* of the two constituents into a frequent binomial.
Note that the two constituents of a binomial are in many instances also semantically related (e.g., Cooper & Ross, 1975). Therefore, an alternative interpretation for our results is that it is the semantic relationship between the two constituents in a binomial that leads to shorter onset latencies and shorter constituent durations (e.g., Swinney et al. 1979). A semantic interpretation was also provided by Jolsvai, McCauley, and Christiansen (2013) who found no frequency effects for the onset latencies of multi-word phrases. However, our results show that shorter onset latencies and constituent durations also occur in a subset of the data, in which the semantic association between the two constituents is low. A further argument against a pure semantic priming account is that the association strength between the two constituents in a binomial (as assessed in a free association task) was not a significant predictor for onset latencies. Therefore, we are confident that our results point to the storage of German binomials as a single unit (like assumed for other, frequently occurring phrases (e.g., Bybee, 2010; Tabossi et al., 2009), rather than to a semantic priming account. However, future studies will have to manipulate the semantic relationship of the constituents in a binomial more explicitly to exclude an explanation that is purely based on semantic priming.

5. Appendix

Table 1: *Original binomials with respective alternative constituent, split for strong (top half) and weak (bottom half) association, English translations in italics*

Original binomial	Alternative to constituent 1	Alternative to constituent 2
Ebbe & Flut/*ebb & flow*	Treppe/*stairs*	Brut/*brood*
Tag & Nacht/*day & night*	Prag/*Prague*	Pacht/*lease*
Pech & Schwefel/ *bitumen & sulfur*	Blech/ *plate*	Frevel/ *iniquity*
Blitz & Donner/ *lightning & thunder*	Sitz/*seat*	Sommer *summer*
Obst & Gemüse/ *fruits & vegetables*	Probst/ *provost*	Kombüse/ *galley*
Leib & Seele/ *body & soul*	Weib/*broad*	Kehle/*throat*
Rat & Tat/*advice & act*	Staat/*state*	Staat/*state*
Hülle & Fülle/ *sleeve & wealth*	Gülle/*slurry*	Gülle/*slurry*
Mann & Frau/ *man & woman*	Bann/*ban*	Stau/*jam*
Berg & Tal/ *mountain & valley*	Werk/*factory*	Stahl/*steel*
Haus & Hof/ *home & yard*	Maus/*mouse*	Boot/*boat*
Feuer & Flamme/ *fire & flame*	Steuer/*tax*	Tanne/*fir*
Tür & Angel/ *door & hinge*	Kür/*kur*	Mangel/*lack*
Luft & Liebe/*air & love*	Duft/*odour*	Fliege/*fly*
Land & Leute/ *country & people*	Hand/*hand*	Meute/*mob*
Rand & Band/ *edge & strap*	Wand/*wall*	Wand/*wall*
Not & Elend/ *need & misery*	Tod/*death*	Gegend/*region*
Saft & Kraft/ *juice & strength*	Haft/*custody*	Haft/*custody*
Sein & Schein/ *being & pretence*	Bein/*leg*	Bein/*leg*
Herz & Nieren/ *heart & kidneys*	Schmerz/*pain*	Viren/*viruses*

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