*Running Head: ARGUMENT STRUCTURE VERSUS ARGUMENT ADJACENCY IN IDIOM
PROCESSING*

*The Wrong Horse was Bet on – The Effects of Argument Structure versus Argument
Adjacency on the Processing of Idiomatic Sentences*

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Link to dropbox folder providing the behavioural data, statistical analyses, and materials:

<https://www.dropbox.com/sh/djy3g550t1dmyra/AADAICYvaCTYevS5ngroaXQ-a?dl=0>

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Abstract

Psycholinguistic research remains puzzled by the question under what circumstances syntactically transformed idioms keep their figurative meaning. In this study we examined the effects of verb argument structure and argument adjacency on the processing of idiomatic and literal sentences in German. In two sentence-completion experiments, participants listened to idiomatic and literal sentences, both in active and passive voice, without the sentence-final verb. They indicated via button-press, which of three visually presented verbs best completed the sentence. Argument structure (i.e. verb transitivity) and argument adjacency (i.e. the adjacency of the verb and its critical arguments) were manipulated across experiments: In Experiment 1, passivized sentences with ditransitive verbs had adjacent arguments and those with transitive verbs had nonadjacent arguments, and vice versa in Experiment 2.

In both experiments, idiomatic sentences were processed faster than literal ones, and active sentences faster than passive ones. In passivized sentences, the patterns of argument structure and argument adjacency reversed across experiments: In Experiment 1, sentences with ditransitive verbs were processed faster than sentences with transitive verbs, and vice versa in Experiment 2. This pattern corresponds to faster processing of adjacent than of nonadjacent arguments and thus points to the dominating role of argument adjacency rather than argument structure in the processing of passivized sentences. With respect to idiom processing, we conclude that the adjacency of the verb and its arguments determines whether passivized idioms keep their figurative meaning.

Keywords: idiomatic sentences; syntactic processing; passive voice; transitivity; argument structure; adjacency

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Adjacency on the Processing of Idiomatic Sentences

In sentence processing, different information is used to construct the meaning of the whole sentence. The verb is at the interface between semantics and syntax and carries more information than other words in a sentence, and is therefore a valuable source of information. One type of information is the lexical representation of the verb (e.g., Healy & Miller, 1970; Levelt, 1989; Pickering & Branigan, 1998), which is assumed to include the argument structure of the verb, that is, the number of arguments a verb takes. The verb *give*, for instance, requires three arguments, namely a subject, a direct object and an indirect object, as in “*Pat gave a cookie to Kim*” (e.g., Bencini & Goldberg 2000). Verbs requiring three arguments like *give* are called ditransitive verbs, verbs requiring two objects like *eat* are called transitive verbs, and verbs requiring one object like *run* are considered intransitive verbs. However, verbs occur in many argument structure configurations (e.g., Goldberg, 1995), resulting in a difficulty to construct the meaning of the sentence based solely on verb information. The verb *kick*, for instance, which is considered to be a prototypical transitive verb, can occur in at least eight argument structure frames (Bencini & Goldberg, 2000). Examples are “*Pat kicked the wall*”, which includes a transitive action, “*Pat kicked the football into the stadium*”, which includes a caused motion, and “*Horses kick*”, which includes an intransitive action. Bencini and Goldberg (2000) show that instead of relying solely on verb information to interpret the meaning of a sentence, the configuration of the arguments of a verb play a crucial role in the interpretation of the sentence as well.

Idiomatic sentences are special when it comes to the reliability of verb information and information regarding the configuration of verb arguments. First, the meaning of the verb in an idiomatic sentence often strongly deviates from its prototypical meaning. For instance, besides occurring in different argument structure frames, the meaning of the verb “*kick*” can have a completely different meaning when it is part of the idiomatic sentence “*Pat kicked the*

1 *bucket*". This sentence does not include a prototypical transitive action as in "*Pat kicked the*
2 *wall*", but the intransitive action of *to die*. Second, the argument structure of the verb in an
3
4 idiomatic sentence often deviates from the prototypical argument structure of the same verb in
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6 a literal sentence. For instance, the verb "*öffnen*" (literal, L: *to open*) in the German idiom
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8 "*jemandem die Augen öffnen*" (L: *to open somebody's eyes*; figurative, F: "*to tell someone a*
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10 *few home truths*"), actually is a transitive verb that requires a subject and an object, whereas
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12 the idiomatic sentence requires an additional indirect object. If this indirect object is not
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14 present, the figurative meaning is lost. In this study, we compare the processing of idiomatic
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16 and literal sentences and introduce the argument structure of an idiom as a potential factor
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18 that determines the processing of idioms. Idioms exhibit a special semantic and syntactic
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20 behaviour, as shown below, and we will focus on the syntactic processing in this study.
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27 Traditionally, idiomatic sentences such as "*to kick the bucket*" or "*to reach for the*
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29 *stars*" are assumed to be semantically fixed, meaning that their individual parts cannot be
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31 substituted without losing the figurative meaning of the idiom, as in "*she reached for the*
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33 *planets*" (e.g., Moon 1998). In addition to their semantic fixedness, idioms are also
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35 considered to be syntactically fixed, because they cannot undergo all syntactic
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37 transformations as literal sentences can (Jackendoff, 1997). Because of this semantic and
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39 syntactic fixedness, traditional theoretical accounts expect idioms to be stored in the mental
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41 lexicon as whole phrases, each phrase carrying its own semantic entry (e.g., Chomsky, 1980;
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43 Jackendoff, 2008; Levelt, 1989; Moon, 1998).
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51 *Semantic Processing of Idioms*

52 Psycholinguistically, this assumption is reflected by noncompositional processing
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54 models such as the idiom list hypothesis (Bobrow & Bell, 1973), the lexical representation
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56 hypothesis (Swinney & Cutler, 1979), and the direct access hypotheses (Gibbs, 1980). Also
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58 hybrid models assume a noncompositional representation of the idiom, in addition to the
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compositional handling of an idiom (see Cacciari & Corradini, 2015; Cacciari & Tabossi, 1988; Cutting & Bock, 1997; Sprenger, Levelt, & Kempen, 2006; Tabossi, Wolf, and Koterle, 2009; Titone & Libben, 2014). The compositional routine is reflected in the assumption that the figurative meaning is composed from the literal meaning of the individual constituents of the idiomatic phrase. According to the configuration hypothesis (Cacciari & Tabossi, 1988), for instance, the figurative meaning is related to a specific configuration that is recognized at a special point in the sentence (the idiom ‘key’). The interpretation of the meaning is completely literal up to that point, and completely figurative from that point on.

However, there is evidence that the activation of the literal meaning is not terminated as soon as the figurative meaning is recognized, but instead remains present during the processing of the entire sentence (Rabanus, Smolka, Streb, & Rösler, 2008; Smolka, Rabanus, & Rösler, 2007). These findings have become the main feature in purely compositional accounts like the stem-based frequency account (e.g., Rabanus et al., 2008; Smolka et al., 2007). More recent studies on the processing of idiomatic sentences further show that idioms are not as semantically fixed as previously assumed (e.g., Geeraert, Newman, & Baayen, 2017; Holsinger, 2013; Smolka & Eulitz, 2020). For example, the stem-based frequency model (Rabanus et al., 2008; Smolka & Eulitz, 2020; Smolka, Preller, & Eulitz, 2014; Smolka et al., 2007) accounts for the fact that the individual constituents of an idiom (e.g., “*stars*” in “*to reach for the stars*”) can be substituted by semantically associated words (e.g., “*planet*”) without losing the figurative meaning. The model assumes the same representations and processes for both idiomatic and literal configurations. Individual stems (i.e. word constituents) are accessed, and their associated mental concepts are activated. The frequency of a particular constituent determines the strength of meaning activation at the concept level, and the activation of individual constituents and their concepts, particular combinations of constituents activate one another and their joint concept (also idiomatic combinations). For instance, the combination “*reach*” and “*stars*” will activate the concept that expresses the

1 figurative meaning “*to try to achieve something impossible*”. The meaning of this concept
 2 will further activate the closely related concept *ambition*. The frequency of a particular
 3 constituent combination (e.g., “*reach*”, “*for*”, and “*stars*”) determines how strongly the
 4 common concept will be activated. Because constituents will always activate their closely
 5 related concepts, literal-meaning associations will be available regardless of the meaning of
 6 the entire phrase. However, although the stem-based frequency model can explain the lexical
 7 flexibility of idiomatic phrases, it has not yet addressed syntactic issues to explain why some
 8 idioms are more syntactically fixed than others are.

19 *Syntactic Processing of Idioms*

20 Even if we assume that idioms possess a compositional meaning, they exhibit
 21 syntactic peculiarities that need to be accounted for. They cannot undergo every syntactic
 22 transformation without losing their figurative meaning, as in “*the stars were reached for by*
 23 *her*”, “*it were the stars she reached for*”, or “*she reached for the bright stars*” (e.g.,
 24 Jackendoff, 1997).

25 The production model by Cutting and Bock (1997) is a hybrid model that tries to
 26 integrate the syntactic properties of the otherwise compositional idioms in form of phrasal
 27 frames. This model is theoretically extended by the superlemma theory (Sprenger et al.,
 28 2006), which integrates a fixed representation of the syntactic properties of the idiom in form
 29 of a ‘superlemma’. According to the superlemma theory, the information relevant to the
 30 syntactic use of an idiom is idiosyncratic and must therefore be encoded in the lexicon. As a
 31 consequence of being idiosyncratic, idiom syntax must be learned through experience. The
 32 superlemma model thus stipulates syntactic restrictions on idiomatic structures and
 33 incorporates syntactic peculiarities related to idiomatic phrases. It does not explain, though,
 34 why some idioms are syntactically more flexible than others are.

In an eye-tracking study, Holsinger (2013) observed that idiomatic processing is not restricted to sentence boundaries, as it should be according to the notion of a superlemma. They rather found that participants activate the figurative meaning even when the critical words (e.g., *kick* and *bucket*) occur across sentence boundaries (e.g., ... *miss the ball when he kicked. The bucket full of orange slices was ...*), that is, in a syntactic environment that is incompatible with the idiom. These findings thus question the role of the superlemma, which should restrict the figurative reading to a specific syntactic structure.

Previous research has found that the factors of syntactic frozenness, transparency, and decompositionality affect the syntactic fixedness, and thus, for instance, the passivizability of idioms to some extent. Syntactic frozenness refers to the degree to which idioms are fixed by means of a frozenness hierarchy (Fraser, 1970). According to this hierarchy, classes of idioms range from completely frozen (“*blow off some steam*”) over less frozen (“*put on some weight*”, “*make up one’s mind*”) to idioms that are not frozen at all (“*lay down the law*”). Frozen idioms cannot undergo even the most simple transformations without losing their figurative interpretation (“**Some steam was blown off at the party*”), whereas nonfrozen idioms may undergo nearly all traditional transformations and still retain their figurative interpretation (“*The law was laid down by her father before she was even twelve*”). While Gibbs and Gonzales (1985) found evidence for the influence of syntactic frozenness on the syntactic variability of idioms, Peterson, Burgess, Dell, and Eberhard (2001) question the importance of this factor. They rather conclude that the syntactic processor always completely parses idiomatic phrases, regardless of whether the idiom is syntactically flexible or syntactically frozen (and thus more strongly lexicalized).

Rather, the transparency of an idiom has been considered as another factor to affect the syntactic fixedness/variability of idioms. An idiom is considered transparent, if the speaker can recover the rationale for the figuration it involves (Nunberg, Sag, & Wasow, 1994). Gibbs and Nayak (1989) found that transparent idioms were syntactically more

flexible than opaque idioms, nevertheless, the factor transparency was outperformed by the factor compositionality in predicting syntactic flexibility. The degree of compositionality is the third critical factor that may affect the syntactic fixedness of idioms. Indeed, Gibbs and Nayak (1989) observed that decomposable idioms are syntactically more flexible than nondecomposable idioms. However, other studies did not confirm these results or yielded even opposite results (see Cutting & Bock, 1997; Peterson et al., 2001; Sprenger et al., 2006; Titone & Libben, 2014). To summarize, studies disagree on how the three factors— syntactic frozenness, transparency, and compositionality—affect the syntactic processing of idioms. That is, it remains unclear, which of the factors determines to what degree idiomatic sentences keep their figurative meaning when they are syntactically transformed.

In this study, we were interested in the syntactic processing of idiomatic sentences and particularly in factors that influence the syntactic fixedness of idioms. To this end, we focused on the passivization of idioms and conducted two sentence completion experiments to investigate how verb information (i.e. verb argument structure) and the adjacency of the arguments influences the processing of idiomatic and literal sentences. To our knowledge, this is the first study that directly compares the effects of argument structure and argument adjacency on the processing of idiomatic sentences.

Experiment 1

In Experiment 1, we investigated the influence of verb information and compared the processing of verbs with different argument structures, namely of transitive and ditransitive verbs.

Prior research was conducted on literal language and studied language acquisition or language production in agrammatic patients and unimpaired participants. Overall, the findings show that the number of arguments required by a verb affects sentence production: higher number of arguments in sentences led to increasing numbers of errors (De Bleser &

Kauschke, 2003; Thompson, Lange, Schneider, & Shapiro, 1997; Thompson, Shapiro, Li, & Schendel, 1995). Thus, sentences with an intransitive argument structure (e.g., “[he] sits”)¹ are easier to produce than sentences with a transitive argument structure (e.g., “[he] fixes [the chair]”), which are again easier to produce than sentences with a ditransitive argument structure (e.g., “[he] gives [her] [the present]”). According to Shapiro, Zurif, and Grimshaw (1987, 1989), the complexity of the argument structure also affects language comprehension. In their study, lexical decision times in healthy participants were slower for verbs like “give”, which requires three arguments, than for verbs like “fix”, which requires only two arguments. Thus, verb properties have been shown to play an important role in the study of literal language, but have been neglected in the psycholinguistic study of figurative language so far.

Most studies on idiom processing (e.g., Gibbs & Nayak, 1989; Peterson et al., 2001; Tabossi et al., 2009) have not manipulated the argument structure and applied a mixture of both transitive and ditransitive verbs (e.g., “to hit [the spot]”, “to play [second fiddle] [to someone]”). Only few studies (e.g., Gibbs, Nayak, & Cutting, 1989; Holsinger, 2013) controlled for the argument structure and employed idioms with a transitive argument structure.

To our knowledge, this is the first study that directly manipulates the verb argument structure of idiomatic sentences and compares the processing of idiomatic sentences that hold transitive verbs with those that hold ditransitive verbs. There are several differences between idioms with a transitive sentence structure and those with a ditransitive sentence structure. First, in most idiomatic sentences with a ditransitive structure of the type “verb [indirect object] [direct object]”, as in “[Sie] hat [der Freundin] [die Augen] geöffnet” (word-by-word, W: “[she] has [the friend] [the eyes] opened”; L: *She opened the friend’s eyes*; F:

¹ Arguments are presented in brackets.

1 “*She told the friend a few hometruths*”), the content of the indirect object (here, *the*
 2 *friend*_{DAT})² does not contribute to the figurative meaning, that is, it does not directly serve as
 3
 4 an idiomatic constituent, since this position can be arbitrarily filled (e.g., *the sister*_{DAT}, *the*
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 6 *teacher*_{DAT}). Nevertheless, the figurative reading requires the ditransitive form of “*öffnen*”,
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 8 because in most cases, omitting the indirect object leads to a literal nonfigurative reading
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 10 (“*[Sie] hat [die Augen] geöffnet*”, L: *She opened the/her eyes*), as the example of the
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 12 transitive form of the verb “*öffnen*” (L: *to open*) shows. Thus, although a semantic analysis of
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 14 the indirect object is not necessary in this idiom, the syntactic system needs this argument in
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 16 order to permit the figurative reading, resulting in a so-called “syntactic-semantic mismatch”
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 18 in the case of ditransitive idioms (see Peterson et al., 2001).

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 24 Second, a transitive idiomatic sentence like “*[She] reached [for the stars]*” usually
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 26 features a literally filled subject slot (“*she*”), and an idiomatically filled direct object slot
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 28 (“*for the stars*”), whereas a ditransitive idiom like “*[She] told [the friend] [a few*
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 30 *hometruths]*” often has a literally filled subject slot (“*she*”), a literally filled indirect object
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 32 slot (“*the friend*”), and an idiomatically filled direct object slot (“*a few hometruths*”). That is,
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 34 transitive idioms have one literally filled slot, while ditransitive idioms often have two
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 36 literally filled slots, so that the number of argument slots that are filled in a literal way in
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 38 ditransitive idioms often outrank those in transitive idioms.

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 44 Third, in ditransitive idiomatic sentences, which show the typical order subject (e.g.,
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 46 “*she*”)–indirect object (e.g., “*the friend*”)–direct object (e.g., “*a few hometruths*”), the
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 48 idiomatic key – the critical argument for recognition of the figurative meaning (e.g., Cacciari
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 50 & Tabossi, 1988) – occurs rather late in the sentence. Thus, the activation of the figurative

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 56 ² DAT refers to the dative case, which, in German grammar, is used to indicate the
 57
 58 recipient or beneficiary of an action.

meaning is expected to begin later on during sentence processing. For example, upon hearing the words “*She gave the friend ...*”, there is no hint that the sentence will become idiomatic. Hence, it is possible that the literal analysis is more prominent in ditransitive idiomatic sentences than in transitive ones.

Furthermore, the prototypical passive sentence features a transitive verb (see Eisenberg, 2006:125), suggesting that this type of sentence might have a processing advantage over other passive sentences. To summarize, there are several reasons why idiomatic sentences with transitive and ditransitive verbs may be processed in different ways, in particular when they are passivized. The aim of the present study was to examine this issue.

Table 1 about here

To this end, we constructed sentence pairs holding the same verb (see Table 1): one with a figurative reading, such as “*Sie hat dem Jungen den Kopf gewaschen*” (L: *She washed the boy’s head*; F: “*She gave the boy a piece of her mind*”), the other with a literal reading, such as “*Er hat der Tochter die Haare gewaschen*” (L: *He washed the daughter’s hair*). In a speeded sentence completion task, participants heard sentences without the sentence-final verb (i.e. up to the word before the last word of the sentence) and then chose which of three visually presented verbs best completed the sentence. One verb was a completion of the figurative meaning (e.g., “*gewaschen*”; L: *washed*), the second verb was a semantic associate of the figurative verb (e.g., “*gereinigt*”; L: *cleaned*), and the third was an unrelated literal control (e.g., “*gemessen*”; L: *measured*). For literal sentences, all verb types (i.e., figurative, semantic associate, unrelated) were meaningful completions of the sentence. As Table 1 demonstrates, the idiomatic and literal sentence pairs had either transitive or ditransitive argument structure.

Our investigation focused on three questions that have been central in the psycholinguistic literature on sentence processing in general and on idiom processing in particular. We discuss these three questions below.

Question 1: Does the underlying processing of idiomatic and literal sentences compare? The majority of studies, which assume some kind of lexical representation of idioms, have found a processing advantage for idiomatic sentences over literal sentences (e.g., Gibbs, 1980; Gibbs & Gonzales, 1985; Swinney & Cutler, 1979). If, however, our assumption holds that idiomatic constituents are processed in the same way as literal ones (Rabanus et al., 2008; Smolka & Eulitz, 2020; Smolka et al., 2007), we expect idiomatic sentences to be processed as fast as literal ones.

Question 2: Does sentence processing differ depending on whether they are in active or passive voice? To our knowledge, there is only one study that compared the online processing of idiomatic active and passive sentences (Kyriacou, Conklin, & Thompson, 2020). In an eyetracking study, Kyriacou et al (2020) found that idiomatic active sentences are processed faster than idiomatic passive sentences. Studies on literal sentence processing have demonstrated that there is a general preference for active over passive sentences (Mehler, 1963). Furthermore, there is a processing advantage of active over passive sentences, at least when certain conditions hold, such as when the event is coded in terms of the actor, or when the hearer's attention is directed to the actor as the logical subject (Olson & Filby, 1972; Tannenbaum & Williams, 1968). We thus expected a processing advantage of active over passive sentences in general, and, if this processing advantage generalizes to idiomatic sentences, we expected a processing advantage of idiomatic active sentences over idiomatic passive sentences as well.

Question 3: Does argument structure (i.e. verb transitivity) affect sentence processing in general and that of idiomatic sentences in particular? It is generally assumed that literal transitive sentences are easier to process than literal ditransitive sentences, as their argument structure is less complex (e.g., Thompson et al., 1995, 1997). If this transitivity effect in literal sentences generalizes to idiomatic sentences, idiomatic transitive sentences will be processed faster than idiomatic ditransitive sentences. Such a finding would also support the

assumption that idiomatic sentences are fully parsed and syntactically analyzed just like literal sentences are (see Peterson et al., 2001; Tabossi et al., 2009).²³

Furthermore, if the argument structure affects the passivization of idiomatic sentences, passivization of ditransitive sentences will be less disruptive (to the figurative meaning) than passivation of transitive sentences, because the former are more ‘literal’, holding two literal objects slots, while the latter hold only one literal object slot. If, however, the argument structure has no influence on the syntactic fixedness of idioms, passivization will lead to a loss of the figurative meaning in both transitive and ditransitive idiomatic sentences alike.

To summarize, the manipulation of sentence type (idiomatic/literal) examines whether the underlying processes of idiomatic and literal sentences compare. The manipulation of voice (active/passive) examines whether idiomatic sentences can be passivized and still retain their figurative meaning. The manipulation of argument structure (transitive/ditransitive) examines whether the transitivity effect for literal sentences generalizes to idiomatic sentences, and finally, whether argument structure affects the passivization of idiomatic sentences.

Method

Participants

Thirty-one students of the University of Konstanz (12 male, 19 female, mean age of 25.5 years) participated in the experiment for five Euros. All were native speakers of German. No participants were dyslexic, and all had normal or corrected-to-normal vision.

²³ In the following, we will use the terms *transitivity* and *argument structure* interchangeably.

Materials

To ensure that all of the idiomatic expressions were acceptable in passive voice, they were selected from the sentence pool that was tested in the sentence completion task described below.

Pretest 1: Sentence completion task for passivized idioms.

We selected 197 German idioms in active voice from the Dictionary of German Idiomatycity (Redewendungen, Duden, 2008). Of these, 75 were transitive and 122 were ditransitive. In the transitive sentence structure, the idiomatic expressions featured one object (e.g., “[nach den Sternen] greifen”; L: *to reach [for the stars]*); in the ditransitive structure, the idiomatic expressions had two objects (e.g., “[jemandem] [den Kopf] waschen”; L: *to wash [someone’s] [head]*).

Each of the idiomatic expressions in active voice was transformed into the canonical passive voice (e.g., Burchert & de Bleser, 2010). Table 1 provides examples and their translations. For instance, the transitive sentence “*Sie hat nach den Sternen gegriffen*” became “*Nach den Sternen wurde von ihr gegriffen*”; and the ditransitive sentence “*Sie hat dem Jungen den Kopf gewaschen*” became “*Dem Jungen wurde von ihr der Kopf gewaschen*”.

The 197 passivized sentences were distributed over six questionnaires, four of these comprised only ditransitive sentences and two comprised only transitive sentences. The same number of literal sentences, also in passive voice and with the same argument structure as the passivized idioms, were added to the questionnaires to yield a proportion of 50% idiomatic sentences and 50% literal sentences.

For the sentence completion task, we followed the same procedure as in Smolka et al., (2007), cast all sentences in the perfect tense, and presented only the participle prefix *ge-* of the main verb (to avoid completions of complex verbs, which are very common in German), such as “*Dem Jungen wurde von ihr der Kopf ge_____*”. The participants’ task was to complete

each item with the verb that best fits the sentence.

A total of 120 German native speakers participated in this pretest. The questionnaires were distributed either in electronic form (over e-mail) or in printed form. For each sentence, we counted the number of idiomatic completions – that is, how often participants specified the verb that provided the figurative meaning of the sentence.

Experimental sentences.

From this sentence pool, we selected 52 idiomatic sentences that fulfilled the following criteria: (a) the passivized idiom had a sentence completion rate higher than 20%, (b) the idiom can be completed by verbs that force a literal meaning of the sentence, and (c) the verb that completed the idiomatic sentence occurred only once in our experimental set.

Appendix A lists all experimental stimuli.

Each of the 52 idiomatic sentences was paired with a literal sentence that held the same main verb, resulting in 52 sentence pairs, for example, figurative (F) “*Sie hat nach den Sternen gegriffen*” (F: *She reached for the stars*) and literal (L) “*Das Mädchen hat nach den Bonbons gegriffen*” (L: *The girl reached for the sweets*). All idiomatic sentences were ambiguous (i.e. they had both a literal and a figurative meaning). Of the 52 sentence pairs, 24 were transitive, that is, with two arguments (“*Sie hat nach den Sternen gegriffen*”), and 28 ditransitive, that is, with three arguments (“*Sie hat dem Jungen den Kopf gewaschen*”). All sentences were presented in both active and in passive voice. All passivized sentences followed the canonical sentence structure (i.e. order of arguments).

All transitive sentences, by definition, lack one argument relative to ditransitive sentences and thus consist of fewer words. To ensure the same number of words across all sentences in active voice, adjectives and adverbs were added to the transitive sentences (“*Sie hat nach den Sternen gegriffen*” became “*Sie hat immer nach den Sternen gegriffen*”, L: *She always reached for the stars*). All sentences in active voice consisted of seven words, and all

sentences in passive voice had eight words. All sentences were presented in perfect tense with the auxiliary verb in second position and the main verb in sentence-final position.

Each sentence pair (a) was completed by the same verb (e.g., *gewaschen* in idiomatic: “*Sie hat dem Jungen den Kopf gewaschen*” and literal “*Er hat der Tochter die Haare gewaschen*”), and thus (b) had the same argument structure. Each sentence was presented in active and in passive voice, resulting in 52 sentence quartets. Of the 52 sentence quartets, 24 had a transitive sentence structure and 28 had a ditransitive sentence structure (see Table 1).

Pretest 2. Sentence completion task for idioms in active voice.

To ensure that all idiomatic and literal sentences were equally comprehensible, we collected sentence completion data for the final set of 52 idiomatic and their 52 corresponding literal sentences in active voice. Again, only the participle prefix *ge-* of the main verb was provided and participants were asked to complete each item with the verb that best fit the sentence. Sentences were randomly distributed over the questionnaire. Twenty-two German native speakers who had not taken part in Pretest 1 participated in Pretest 2. The mean sentence completion rate for the expected verb that rendered the figurative meaning, henceforth “figurative verb”, was 76% in idiomatic sentences, and 52% in literal sentences. With respect to idiomatic sentences, 82% of the transitive sentences and 72% of the ditransitive sentences were completed with the figurative verb. With respect to literal sentences, 54% of the transitive and 50% of the ditransitive sentences were completed with the ‘figurative’ verb. Overall, these figures assure that the sentence-final verbs were highly expected⁴.

⁴ Like in our study, Cacciari & Tabossi (1988) investigated idiomatic sentences that could be completed in both a literal and an idiomatic way. Completion rates (two words from the end) were 45% for the nine idiomatic sentences (compared to 76% in our study).

Targets.

For each idiomatic sentence, three types of verb targets were selected: (a) the figurative verb, such as “*gegriffen*” (L: *reached (for)*) in the sentence “*Sie hat immer nach den Sternen _____*”, (b) a semantic associate of the figurative verb, such as “*gelangt*” (L: *aimed (at)*), and (c) a verb unrelated to the figurative verb, such as “*gelebt*” (L: *lived*). All verbs completed the sentence in a meaningful way: (a) in a figurative reading, (b) and (c) in a literal reading. The literal sentences were completed by the same (a) figurative verb, such as “*gegriffen*” (L: *reached (for)*) in the sentence “*Das Mädchen hat nach den Bonbons _____*”, and by the same (b) semantic associate of the figurative verb, such as “*gelangt*” (L: *aimed (at)*). In some cases, (c) the unrelated verb, such as “*getastet*” (L: *fumbled*) differed from the figurative triplet. All three verbs completed the sentence in a literal way.

The three verbs of a verb triplet were matched for number of letters, number of syllables, and lemma frequency (according to CELEX, Baayen, Piepenbrock, & van Rijn, 1993) as best as possible. See Table 2 for a complete list of matched variables for the verb triplets.

Table 2 about here*Filler sentences and targets.*

As fillers, we selected 72 literal transitive and 84 literal ditransitive sentences in active voice. All sentences featured verbs other than the verbs of the experimental set. Each literal filler sentence in active voice was transformed into passive voice, resulting in 156 sentence pairs. The high proportion of filler sentences resulted in a ratio of idiomatic to literal sentences of 20:80, and in a ratio of experimental to filler sentences of 40:60.

The active and passive versions of the same sentence pair were allocated to two lists by means of a Latin square design, yielding 156 literal filler sentences in each list.

Apparatus

The complete sentences were recorded in a quiet and neutral manner by a female native speaker of German, a 36-year-old woman who originated from Frankfurt. The recording took place in a sound-attenuated cabin in the Phonological Lab at the University of Konstanz. The audio files were further arranged and normalized using the PRAAT software package (Boersma & Weenink, 2009).

The auditory stimuli were presented via Sennheiser headphones (HD 595). The visual stimuli were presented on a 17" flat-screen monitor (Flatron L1810B) connected to a BEST personal computer. Response latencies were recorded via a key press on a three-button push-button box connected to the parallel port. The experiment was conducted using the *Presentation* software developed by Neurobehavioral Systems (<http://www.neurobs.com/>).

Design and Procedure

Experimental idiomatic and literal sentences of a sentence pair were allocated to two lists: the idiomatic sentence in active voice was paired with the literal sentence in passive voice in one list, and vice versa in the second list. In total, each list comprised 260 sentences: 26 idiomatic active and 26 idiomatic passive sentences, 26 literal active and 26 literal passive sentences, 78 literal active and 78 literal passive filler sentences. Half of all sentences had a transitive sentence structure, and the other half had a ditransitive structure.

Participants were randomly assigned to one of the two lists. Each list was further subdivided into four blocks of 65 trials each, each block containing 26 experimental sentences (thirteen idiomatic and thirteen literal sentences) and 39 filler sentences. The ordering of the sentences was pseudorandomized for each participant: Shuffling was repeated such that a maximum of four sentences in the same condition were presented consecutively. Sixteen filler sentences (half in active voice, half in passive voice, half with transitive sentence structure, half with ditransitive structure) functioned as practice trials prior to the experiment.

Participants were tested individually in a dimly lit lab. The viewing distance was about 70 cm from the screen. Each trial began with the presentation of a fixation cross in the center of the screen. After 500 ms, the audio file started; the fixation cross remained on the screen until the audio file had finished. At the end of the audio file, the three target verbs were presented in horizontal alignment in a central position, in randomized order from left to right. The verbs were shown in white on a black background in a sans-serif font, size 24. The verbs were displayed until the participant responded via a button press. The left button corresponded to the left-most verb, the middle button to the middle verb, and the right button to the right-most verb. Responses were made with the index finger of the dominant hand. Participants were asked to decide as quickly as possible which verb completed the sentence in the most meaningful way. The experiment lasted about 30 minutes. Breaks between the blocks were self-paced by the participants.

Results

The data of one participant with a bilingual background who had extremely slow response times (mean = 2887 ms) were removed, so that a total of 30 participants were included in the data analyses. Reaction times (RTs) exceeding three standard deviations from a participant's mean were excluded (1.4% of the overall data). Mean response latencies were calculated for those responses where participants completed the sentence with the intended verb. Idiomatic sentences were completed with the figurative verb in 89% of the cases, literal sentences in 80% of the cases.

We used R (R Core Team, 2012) and lme4 (e.g., Baayen, Davidson, & Bates, 2008; Bates, 2005) to perform linear mixed effects analysis. We applied a forward procedure for the model selection, starting with a minimal model and adding additional predictors only when they improved the model fit. The best model fit was obtained by comparing the Akaike

Information Criterion (AIC) statistics between models, with a difference between models > 4 (Sakamoto, Ishiguro, & Kitagawa, 1986).

Latency Data

In the following analyses, we treated Participants and Sentence Pair (holding the same verb) as random effects. The fixed-effect factors of interest were Sentence Type (idiomatic/literal), Voice (active/passive), and Transitivity (transitive/ditransitive). In addition, we tested the influence of the distributional variables Target Frequency (in log-transformed and centered absolute lemma frequencies) and Target Length (number of letters) as well as the confounding factors List and Block. The best model included the factors Sentence Type, Voice, Transitivity, and the interaction between Voice and Transitivity, as well as Target Length. Table 3 summarizes the results. The left panel of Figure 1 depicts the interaction between Voice and Transitivity.

The effects of Sentence Type and Voice indicated that, generally speaking, idiomatic sentences were processed faster than literal sentences, and sentences in active voice were processed faster than sentences in passive voice. The interaction indicated that Transitivity did not affect sentences in active voice, that is, active sentences with ditransitive and transitive argument structures were processed equally fast. By contrast in passive voice, sentences with a ditransitive argument structure were processed significantly faster than sentences with a transitive argument structure. Importantly, this pattern showed in both idiomatic and literal sentences (see the left panel of Figure 1). The factor Target Length showed that a higher number of letters increased target selection.

Table 3 about here

Completion rates

In the sentence completion task, participants chose the target from among three verb candidates. It is important to note that all three verb candidates completed the literal sentences

in a meaningful way. Because there are no errors in the classical sense, we do not report a completion analysis for literal sentences. For idiomatic sentences, we defined the type of sentence completion as ‘figurative’ when participants chose the verb that completed the sentence figuratively, and as ‘literal’ when participants chose one of the verbs that completed the sentence literally (i.e. the semantic associate or the unrelated verb). In the following analysis, we analyse the literal (i.e. nonfigurative) completions of idiomatic sentences.

The completion rates were analyzed using multilevel logistic regression, with random intercepts for Participants and Items, and the fixed-effect factors Voice (active/passive), Transitivity (transitive/ditransitive), and Target Length (number of letters). As summarized in Table 4, the best model included an interaction of the two factors Voice and Transitivity. As in the RT analysis, Transitivity did not affect sentences in active voice, that is, active sentences with transitive and ditransitive argument structures did not differ in terms of literal completion rates (7% and 9%, respectively). By contrast, in passive voice, sentences with a transitive argument structure (21%) induced significantly more literal completions than sentences with a ditransitive argument structure (9%).

Table 4 about here

Figure 1 about here

Discussion

In Experiment 1, we examined whether (1) sentence type, (2) voice, and (3) argument structure (i.e. transitivity) affected sentence processing. Our results were straightforward: First, idiomatic sentences were processed faster than literal ones (e.g., Gibbs, 1980; Gibbs & Gonzales, 1985; Swinney & Cutler, 1979), and active sentences were processed faster than passivized ones. Most importantly, these findings indicate that the effect of voice is generalized to idiomatic sentences, indicating that the same principles that hold for literal sentences hold for idiomatic sentences as well (Tabossi et al., 2009). The effects of sentence

type and voice replicate previous findings, which we will discuss in more detail in the general discussion.

Contrary to previous findings, we observed a reversed transitivity effect, though only in passive voice, that is, better performance in ditransitive than in transitive passivized sentences. Because this (voice by transitivity) interaction held for both literal and idiomatic sentences, it suggests that idiom syntax is principled, not idiosyncratic. This finding is further corroborated by the completion data with better performance (i.e. fewer literal completions) of ditransitive than of transitive passivized idiomatic sentences. In light of our results, we need to reinterpret the previously observed transitivity effect (e.g., Thompson et al. 1995, 1997) in different terms. Previous studies examined the transitivity effect in literal sentences that were in active voice, while in our study, there was no transitivity effect detected in active voice, neither in idiomatic nor in literal sentences. On the contrary, the transitivity effect occurred in passive (idiomatic and literal) sentences and in the opposite direction, with faster (and, in the case of idiomatic sentences more correct) processing of ditransitive than of transitive sentence structure. This finding thus supports our assumption that ditransitive idiomatic sentences may be perceived as more ‘literal’ than transitive ones, because they take two literally filled argument slots (as compared to one in transitive sentences). Therefore, we expected that passivization is less disruptive to ditransitive than to transitive idiomatic sentences. This prediction is borne out by the results of Experiment 1.

Another explanation for the processing advantage of ditransitive passive sentences over transitive passive sentences is argument adjacency. That is, the verb and its arguments that constitute the idiom were adjacent in ditransitive but not in transitive passivized idiomatic sentences, compare ditransitive *Dem Jungen wurde von ihr [der Kopf] [gewaschen]* and transitive *[Nach den Sternen] wurde von ihr [gegriffen]*. It is possible that, in order for the listener to compute the figurative meaning of a passivized idiomatic sentence, the verb and its arguments that carry the figurative meaning need to be adjacent. This difference in adjacency

between transitive and ditransitive sentences in passive voice may have resulted in the processing differences observed in Experiment 1. In that case, argument adjacency, not argument structure, is the influential factor. We conducted Experiment 2 to test this prediction.

Experiment 2

In Experiment 2, we investigated whether argument adjacency or argument structure (i.e. verb transitivity) is more critical for the preservation of the figurative meaning in passivized idiomatic sentences. We predicted that the co-occurring constituents of an idiom are sensitive to adjacency.

In Experiment 1 we passivized all sentences in the canonical way. The canonical sentence structure of a ditransitive passivized sentence is a structure where the the verb and the argument that constitutes the idiom (henceforth “the idiomatic argument”) are adjacent, as in *Dem Jungen wurde von ihr [der Kopf] [gewaschen]*. By contrast, in the canonical structure of a transitive passivized sentence, the idiomatic argument is nonadjacent to the verb, as in *[Nach den Sternen] wurde von ihr [gegriffen]*. In Experiment 1, the canonical passivization thus confounded the factors argument structure and argument adjacency.

In Experiment 2, we applied noncanonical passivization so as to reverse the argument adjacency for the transitive and ditransitive argument structures. This resulted in transitive passivized sentences with idiomatic arguments that are adjacent to the verb (e.g., *Von ihr wurde [nach den Sternen] [gegriffen]*), and in ditransitive passivized sentences with idiomatic arguments that are nonadjacent to the verb (e.g., *[Der Kopf] wurde dem Jungen von ihr [gewaschen]*). This enabled us to examine the factor *argument adjacency* (adjacent/nonadjacent) more closely.

As far as we know, only few psycholinguistic studies investigated the influence of constituent adjacency. In the field of verb-particle constructions (e.g., “look up” in “he

looked up the word” versus “*he looked the word up*”), Gonnerman and Hayes (2005) found that shifted verb-particle structures were harder to process when long nominal phrases intervened between the verb and the particle, indicating that this type of sentence is highly sensitive to adjacency. In the field of collocations (e.g., “*provide information*” versus “*provide some of the information*”), Vilkaitė (2016) showed that collocations have a general processing advantage over control phrases, and that this finding extends to nonadjacent collocations, even though the facilitative effect of collocations might be larger for adjacent than for nonadjacent collocations. Adjacency has been shown to play a role in the field of natural language processing (NLP), when it comes to the identification of idiomatic sentences. Hashimoto and Kawahara (2008) examined how ambiguous idioms are identified by two kinds of information, namely word sense disambiguation (WDS) features (e.g., single words in the surrounding context) and idiom-specific features (e.g., the adjacency of constituents). The results show that WDS features lead to a very high number of correct identifications (88.9%), and that adding idiom-specific features leads to an even higher number of correct identifications (89.3%). Crucially, among the idiom-specific features, adjacency was the most important factor. These findings demonstrate that constituent adjacency plays an important role in the processing of typically co-occurring instances in a language, such as verbs and their particles, and words in collocations. In our study, we extend this research to the examination of idiomatic sentences, in particular passivized ones. This study is thus the first psycholinguistic study to investigate the influence of argument adjacency on the processing of idiomatic compared to literal sentences, be they active or passive.

As mentioned above, in order to manipulate the adjacency of the arguments, we modified the syntactic structure of the sentences. To that end, we compared active and passive idiomatic and literal sentences. Our study is the first that addresses the influence of (a) verb argument structure (i.e. transitivity), and (b) argument adjacency on the syntactic processing of idiomatic sentences. Specifically, we examined the processing of German idioms with either

transitive or ditransitive sentence structures and manipulated the sentence structure to achieve different adjacencies of the arguments. This manipulation was the canonical versus noncanonical passivization. In Experiment 1, we passivized all sentences in a canonical way. In the case of transitive sentences, the passivized version was (“*[Nach den Sternen] wurde immer von ihr [gegriffen]*”), where the argument constituting the idiom and the verb were nonadjacent. In the case of ditransitive sentences, the passivized version was (“*Dem Jungen wurde von ihr [der Kopf] [gewaschen]*”), where the argument constituting the idiom and the verb were adjacent. Note that in the case of idioms (e.g., “*kick the bucket*”), the direct object (“*the bucket*”) and the verb (“*kick*”) are often the key constituents of the idiom. In Experiment 2, we reversed these alignments in order to yield passivized transitive sentences where the critical argument and the verb were adjacent (“*Von ihr wurde [nach den Sternen] [gegriffen]*”), and passivized ditransitive sentences where the critical argument and the verb were nonadjacent (“*[Der Kopf] wurde dem Jungen von ihr [gewaschen]*”). Note that this is possible because of the word-order variation in German.

If indeed, argument structure affects processing time, that is, more arguments lead to longer processing times (Shapiro et al. 1987, 1989), we should find faster processing of transitive than of ditransitive sentences, irrespective of the adjacency of the arguments. If, however, the argument adjacency is the more influential factor, sentences with critical arguments adjacent to the verb should be processed faster than sentences with critical arguments nonadjacent to the verb. Such a finding would corroborate those of Experiment 1 where ditransitive passivized sentences showed a processing advantage over transitive sentences; and in Experiment 2, we should see that transitive passivized sentences show a processing advantage over ditransitive sentences. Third, if idiomatic and literal sentences underlie the same processing mechanisms, the same effects should arise for idiomatic and literal sentences.

To summarize, we asked the same questions regarding the effects of sentence type and voice as in Experiment 1 – *Does the underlying processing of idiomatic and literal sentences and that of active and passive sentences compare?* – and expected faster processing of idiomatic over literal sentences, and faster processing of active over passive sentences, respectively. In Experiment 2, we expanded our third question – whether argument structure (i.e. verb transitivity) affects sentence processing – to include the question: *Does argument adjacency (i.e. the adjacency of the critical argument and the verb) affect sentence processing in general and that of idiomatic sentences in particular?* If argument structure affects the preservation of the figurative meaning in passivized sentences, the results of Experiment 1 (faster processing of ditransitive over transitive sentences) will replicate. If, however, argument adjacency exerts a greater influence on the preservation of the figurative meaning in passive sentences, passivized idiomatic sentences with idiomatic arguments adjacent to the verb (i.e. transitive sentences in Experiment 2) will show a processing advantage over those with idiomatic arguments nonadjacent to the verb (i.e. ditransitive sentences in Experiment 2).

Method

Participants

Thirty students (6 male, 24 female, mean age of 22.9 years) at the University of Konstanz who did not take part in Experiment 1 were paid five euros for their participation. All were native speakers of German. No participants were dyslexic, and all had normal or corrected-to-normal vision.

Materials

Appendix B lists all the stimuli of Experiment 2. The stimulus materials were the same as in Experiment 1, with a few exceptions. First, the sentences in passive voice differed in their argument adjacency: The transitive passive sentences of Experiment 1, in which the idiomatic argument was nonadjacent to the verb (*“[Nach den Sternen] wurde immer von ihr*

[gegriffen]”), had an adjacent configuration in Experiment 2 (“Von ihr wurde immer [nach den Sternen] [gegriffen]”). The ditransitive passive sentences of Experiment 1, in which the idiomatic argument was adjacent to the verb (“Dem Jungen wurde von ihr [der Kopf] [gewaschen]”), had a nonadjacent configuration in Experiment 2 (“[Der Kopf] wurde dem Jungen von ihr [gewaschen]”). Second, the sentences in active voice differed in their adjacency: All active sentences were transformed from an unmarked structure with idiomatic arguments being adjacent to the verb into a marked structure with a topicalized object, resulting in a structure where the idiomatic arguments were nonadjacent to the verb. Thus, all sentences featured an unmarked sentence structure in Experiment 1 and a marked sentence structure in Experiment 2. It is possible that idioms with a structure where the critical argument is not adjacent to the verb are more strenuous to working memory than adjacent configurations are. Because this effect may be more pronounced in auditory than in visual presentation mode, we changed the modality of the sentence presentation from auditory in Experiment 1 to visual in Experiment 2. Table 5 lists all eight conditions of Experiments 1 and 2.

Table 5 about here

The sentence structures of the literal sentences and the filler sentences were adapted to match the structure of the idiomatic sentences. Other than these changes in sentence structure, all sentences and verb targets, as well as the proportion of experimental and filler sentences were the same as in Experiment 1.

Apparatus

The stimuli were presented on a 17” flat-screen monitor (Flatron L1810B) connected to a BEST personal computer. Response latencies were recorded via a key press on a three-button push-button box connected to the parallel port. The experiment was conducted using

the *Presentation* software developed by Neurobehavioral Systems (<http://www.nbs.neuro-bs.com>).

Procedure

Each trial began with the presentation of a fixation cross in the center of the screen for 500 ms. At the offset of the fixation cross, the words of a sentence were presented at once in the middle of the screen, with the fourth (i.e. the middle) word aligned in the center of the screen. The sentence remained on the screen until the participant responded via a button press, after which the three target verbs were presented in horizontal alignment in a central position (and in randomized order from left to right). The sentence and the verbs were shown in white on a black background in a sans-serif font, size 26 and 24, respectively. All other experimental conditions were the same as in Experiment 1.

Results

One participant with extremely high nonfigurative verb completions (> 50%) was removed, so that a total of 29 participants were included in the data analyses. Reaction times (RTs) exceeding three standard deviations from a participant's mean were excluded (1.3% of the overall data). Mean response latencies were calculated for those responses where participants completed the sentence with the figurative verb. The figurative verb was used to complete 87% of the idiomatic sentences, and 77% of the literal control sentences. Note that all verb completions resulted in meaningful sentences, so that there is no error count in the classical way.

As in Experiment 1, we performed linear mixed effects analysis using R (R Core Team, 2012) and lme4 (e.g., Baayen et al., 2008; Bates, 2005), and applied a forward procedure for the model selection. The best model fit was obtained by comparing the Akaike Information Criterion (AIC) statistics between models (Sakamoto, Ishiguro, & Kitagawa, 1986).

Latency data

As in Experiment 1, we treated Participants and Sentence Pair (holding the same verb) as random effects, and examined the fixed-effect factors Sentence Type (idiomatic/literal), Voice (active/passive), and Transitivity (transitive/ditransitive). In addition, we tested the influence of Target Frequency (in log-transformed and centered absolute lemma frequencies), Target Length, List, and Block.

The best model included the factors Sentence Type, Voice, Transitivity, the three-way interaction of these three factors, as well as Target Length. Table 6 summarizes the results; the right panel of Figure 1 depicts the interaction.

As in Experiment 1, idiomatic sentences were processed (marginally) faster than literal ones, and sentences in active voice were processed faster than those in passive voice. The significant three-way interaction indicated that the pattern of the Transitivity by Voice interaction (that also emerged in Experiment 1) showed only in idiomatic, but not in literal sentences. With respect to idiomatic sentences, active sentences with transitive and ditransitive argument structures were processed equally fast. By contrast in passive voice, sentences with a transitive argument structure were processed significantly faster than sentences with a ditransitive argument structure. Again, the factor Target Length showed that the increasing number of letters prolonged target selection.

[Table 6 about here](#)

Completion rates

As in Experiment 1, we defined the type of sentence completion as ‘figurative’ when participants chose the verb that completed the sentence figuratively, and as ‘literal’ when participants chose one of the verbs that completed the sentence literally. We report the literal completions of idiomatic sentences.

As in Experiment 1, the completion rates were analyzed using multilevel logistic

regression, with random intercepts for Participants and Items, and the fixed-effect factors Voice (active/passive), Transitivity (transitive/ditransitive), and Target Length (number of letters). As Table 7 summarizes, only the effect of Voice was significant. Nevertheless, as expected, the mean completion rates point to a reversed pattern as the one found in Experiment 1, with more literal completions in the passivized ditransitive sentences (17%) than in the passivized transitive (9%) sentences, and no difference between ditransitive and transitive active sentences (12% and 9%, respectively).

Table 7 about here

Discussion

In Experiment 2, we investigated whether the adjacency of the critical arguments and the verb affects the preservation of the figurative meaning in passivized idiomatic sentences. To this end, we transformed the sentences of Experiment 1 in such a way that transitive passivized sentences with critical arguments and the verb being nonadjacent in Experiment 1 became adjacent in Experiment 2, and vice versa for ditransitive passivized sentences. With regard to the main effects, we replicated the findings of Experiment 1: Idiomatic sentences had a processing advantage over literal sentences, and sentences in active voice had a processing advantage over sentences in passive voice. Crucially, the direction of the interaction between Transitivity and Voice, whereby ditransitive passivized sentences had a processing advantage over transitive passivized sentences in Experiment 1, did not replicate. On the contrary, in Experiment 2, idiomatic transitive passivized sentences had a processing advantage over ditransitive sentences. The completion rates further supported this result. That is, transitive passivized sentences in which the idiomatic arguments were adjacent to the verb had a processing advantage over ditransitive passivized sentences in which the idiomatic arguments were nonadjacent to the verb. In light of the fact that in Experiment 2, transitive passivized idioms had an adjacent argument-verb configuration, and ditransitive passivized

idioms had a nonadjacent argument-verb configuration, this finding supports our hypothesis that the adjacency of the arguments constituting the idiom and the verb affects the preservation of the figurative meaning in passivized sentences.

Post-hoc Analysis: Argument Structure versus Argument Adjacency

To examine whether the factor argument adjacency (i.e. the adjacency of the critical arguments and the verb) may be a better predictor in determining idiomatic processing than argument structure (i.e. verb transitivity) we conducted the following post-hoc analyses for the combined data of Experiments 1 and 2. To examine the influence of adjacency, we coded the factor Adjacency in such a way that its adjacent level included a) all active sentences (transitive and ditransitive) of Experiment 1, (b) the passive ditransitive sentences of Experiment 1, and (c) the passive transitive sentences of Experiment 2; its nonadjacent level included (a) all active (transitive and ditransitive) sentences of Experiment 2, (b) the passive ditransitive sentences of Experiment 2, and (c) the passive transitive sentences of Experiment 1.

We used R and lme4 to perform linear mixed effects analysis. As in Experiments 1 and 2, we treated Participants and Sentence pair (holding the same verb) as random effects, and included the fixed effects Sentence Type (idiomatic/literal), Voice (active/passive), and Target Length (number of letters). We then compared by means of the Akaike Information Criterion (AIC), whether the inclusion of the factor Argument Structure (transitive/ditransitive) or Argument Adjacency (adjacent/nonadjacent) better improved the model. As indicated by the AIC in Table 8, the factor Argument Adjacency provided a better model fit. Furthermore, because an interaction with Sentence Type did not improve the model, we may assume that Adjacency affects both idiomatic and literal sentences. Figure 2 depicts the influence of the Factor Adjacency.

[Table 8 about here](#)

Figure 2 about here

The post-hoc analysis confirmed the effect of argument adjacency, in that sentences with adjacent arguments were processed faster than sentences with nonadjacent arguments. Thus, the results of Experiment 2 and the post-hoc analysis confirm the hypothesis that argument adjacency rather than argument structure (i.e. transitivity) determines whether passivized idiomatic sentences preserve their figurative meaning.

General Discussion

In the present study, we conducted two sentence completion experiments in which participants decided which of three verbs was the best target to complete a sentence. In Experiment 1, we examined whether (1) sentence type, (2) voice, and (3) argument structure (i.e. verb transitivity) affected sentence processing. In Experiment 2 and in the post-hoc analysis, we examined whether (1) sentence type, (2) voice, (3) and the adjacency between the verb and the idiomatic arguments affected sentence processing.

We compared the processing of idiomatic versus literal sentences, and the processing of active versus passive sentences. Furthermore, we asked whether the factors argument structure and argument adjacency affect the processing of idiomatic and literal sentences. Overall, we focused on three core questions:

Question 1: Does the underlying processing of idiomatic and literal sentences compare?

Question 2: Does sentence processing differ depending on whether they are in active or passive voice?

Question 3: Does argument structure (i.e. verb transitivity) or argument adjacency (i.e. the adjacency between the verb and its arguments) affect sentence processing in general and that of idiomatic sentences in particular?

In summary, we take our results to have shown that the answer to Questions 1 and 2 is “yes”, and that the answer to Question 3 is “yes, argument adjacency”. We elaborate on these questions below.

With respect to question 1, our results were straightforward: First, idiomatic sentences were processed faster than literal ones (e.g., Gibbs, 1980; Gibbs & Gonzales, 1985; Swinney & Cutler, 1979). According to noncompositional lexicalization theories, this may indicate that idiomatic sentences are stored as lexicalized units and are thus processed faster than literal sentences, in which the meanings of individual words must be computed and integrated into a structure. However, fast processing has also been observed for less idiosyncratic multi-word units, such as clichés (Tabossi et al., 2009) and frequent multi-word expressions (Arnon & Snider, 2010). Another reason for faster processing of idiomatic over literal sentences in our study may have been the fact that the figurative verbs were better clozures of the idiomatic sentences than of the literal sentences, which is reflected in higher sentence completion rates for idiomatic than for literal sentences in active voice (76% versus 52%, see pretest 2 above). High sentence completion rates reflect the predictability of idiomatic sentences. Notably, predictable idioms are read faster than unpredictable idioms (Cacciari & Corradini, 2015), and reading some of the constituent words of highly predictable idioms may suffice to pre-activate words that are more likely to appear (Molinaro, Barraza, & Carreiras, 2013; Molinaro & Carreiras, 2010; Vespignani, Canal, Molinaro, Fonda, & Cacciari, 2010). Indeed, when sentence completion rates were equivalent for idiomatic and literal sentences (see Rabanus et al., 2008; Smolka et al., 2007), we found no processing difference between idiomatic and literal sentences. Therefore, the faster processing of idiomatic sentences in the present study may result from the fact that idiomatic sentences were more predictable than literal sentences.

Question 2 asked whether passive sentences are processed differently from active ones, and whether this effect is generalized to idiomatic sentences. Again, our results were straightforward: Active sentences were processed faster than passivized ones, and this effect

was observed for both idiomatic and literal sentences (see also Kyriacou et al., 2020). The completion rates further supported this finding for idiomatic sentences. That is, the effect of voice is generalized to idiomatic sentences, indicating that the same principles hold for both literal and idiomatic sentences (Tabossi et al., 2009). We interpreted these results as corroborating evidence for the claim that the syntactic processing of idiomatic sentences features the same underlying principles as the syntactic processing of literal sentences.

Question 3 asked whether argument structure (i.e. verb transitivity) or rather argument adjacency (i.e. the adjacency of the critical arguments and the verb) affects sentence processing in general and of idiomatic sentences in particular. In Experiment 1, we found an effect of argument structure for both idiomatic and literal sentences in that ditransitive sentences in passive voice were processed faster than transitive sentences in passive voice. We concluded that the same underlying principles govern the processing of idiomatic and literal sentences.

The main goal of the present study was to investigate whether the argument structure of a sentence (transitive or ditransitive argument structure) or whether the configuration of the arguments affects the passivization of idioms – namely, whether they can be passivized without losing their figurative meaning. In Experiment 1, the transitive and ditransitive passivized sentences differed in the adjacency of their critical arguments to the verb. In Experiment 2, we therefore changed the sentence structure of all sentences and investigated whether the adjacency of the verb and its arguments affects the passivizability of idiomatic sentences. This time, transitive passivized sentences with idiomatic arguments adjacent to the verb had a processing advantage over ditransitive passivized sentences with idiomatic arguments that were nonadjacent to the verb. The post-hoc analysis further supported the finding that argument adjacency rather than argument structure affects sentence processing, in particular that of passivized idiomatic sentences.

Discussion of Models on Idiom Processing

Overall, our results support the assumption that idiom syntax is not as idiosyncratic as previously assumed, and is rather governed by the same principles as the syntax of literal sentence processing (Tabossi et al., 2009). In the following, we consider the compatibility of our findings with current models of idiom processing.

According to Cacciari and Tabossi's (1988) configuration hypothesis, a sentence is analyzed figuratively as soon as the idiom is recognized. The point at which it is recognizable as an idiom is referred to as the 'idiom key'. According to these authors, a sentence in which the idiom key occurs early on will be processed faster than a sentence in which the idiom key occurs later on. The direct object of transitive and ditransitive idioms plays a vital role in constituting the figurative meaning. In fact, in some idioms, the direct object represents the idiom key (e.g., *[den Kopf]* in "*jemandem [den Kopf] waschen*"; F: "*to give someone [a piece of his/her mind]*"). Thus, according to the configuration hypothesis, passivized idiomatic sentences that feature this critical argument in a sentence-initial position should be processed faster (e.g., "*[Der Kopf] wurde dem Jungen von ihr gewaschen*") than those with this critical argument in a sentence-medial position (e.g., "*Dem Jungen wurde von ihr [der Kopf] gewaschen*"). However, our findings of 1 showed that sentences with an early idiom key (e.g., "*[Der Kopf] wurde dem Jungen von ihr gewaschen*") exhibited the highest processing costs of all idiomatic sentences, a finding that contradicts the configuration hypothesis.

According to the superlemma theory (Sprenger et al., 2006), the syntactic restrictions of individual idioms are captured in the superlemma entry for each idiom, independently of other factors like compositionality. If syntactic restrictions were independent of other factors, we should find effects neither of argument structure nor of argument adjacency. However, we observed effects of both argument structure and argument adjacency in Experiments 1 and 2, a result that cannot be derived from the predictions of the superlemma theory. Furthermore, as

pointed out by previous studies (e.g., Holsinger, 2013; Tabossi et al., 2009), the restrictions stated by the superlemma should always apply, without exceptions and without gradient. That is, if the superlemma contains the information that an idiom such as “*to reach for the stars*” cannot be passivized, the idiom should be unacceptable in any passivized form, irrespective of whether it is canonical or not. However, in our study, participants did not reject passivized idioms in general, but only those sentences in which the idiomatic arguments were not adjacent to the verb, so that our findings do not support the superlemma account.

The stem-based frequency account (Rabanus et al., 2008; Smolka & Eulitz, 2020; Smolka et al., 2007) assumes that idiom processing resembles literal processing and therefore makes no specific predictions about the syntactic processing or the syntactic restrictions of idiomatic phrases. According to this account, a combination of word constituents – for instance “*reach*” and “*stars*” – activates the concept that expresses the figurative meaning “*to try to achieve something impossible*”. At the concept level, the meaning of this concept will further activate the closely related concept *ambition*. Importantly, the frequency of a particular word combination determines how strongly the common concept will be activated. At this point, we elaborate on the term ‘word combination’, an expression that does not specify how close the combination’s constituents need to be. For instance, one syntactic operation that is often used in studies on the syntactic flexibility of idioms is adverb insertion, which is widely recognized as the most easily accepted manipulation (see Gibbs & Nayak, 1989; Tabossi, Fanari, & Wolf, 2008; Tabossi et al., 2009). For example, the Italian idiom “*toccare il fondo*” (L: *touch the bottom*; F: “*reach rock bottom*”) can be turned into “*toccare purtroppo il fondo*” (L: *touch unfortunately the bottom*) without losing its figurative meaning (Tabossi et al., 2009). The constituents of the idiom occur in combination, but there is a distance between them due to the adverb insertion. The question is how large this distance can be without losing the figurative meaning. According to the results of research on adverb insertion, a certain distance between the constituents of an idiomatic combination is possible,

but the results of the present study indicate that this distance cannot be arbitrarily large.

Consequently, information about the distance between idiomatic arguments (i.e. the adjacency of arguments) should be integrated into the stem-based frequency account. The results of our study suggest that the fewer nonidiomatic arguments that intervene between idiomatic arguments (in other words, the more adjacent the idiomatic arguments), the more likely the figurative meaning will be retained.

According to Smolka and colleagues, the processing of idiomatic and literal sentences does not differ, and both types of sentences can be combined in one model. Indeed, in Experiment 1, we found that idiomatic and literal sentences differ neither with regard to the main effect of voice (active faster than passive) nor with regard to the interaction of voice and transitivity (ditransitive sentences were faster than transitives in passive but not in active voice). In Experiment 2, the main effect of voice was, again, observed for both idiomatic and literal sentences (active faster than passive). These results show that idiom syntax operates by the same principles as the syntax of literal sentences. However, the interaction of voice and transitivity in Experiment 2 (transitive sentences faster than ditransitives in passive voice, but not in active voice) was observed for idiomatic sentences only. This suggests that idiomatic sentences are more sensitive to the adjacency constraint than literal sentences are, probably because of the strong collocations associated with idioms. Although there are many collocations in literal language as well, the collocations of the idiomatic sentences in our study seemed to be stronger, as reflected by the higher sentence-completion rates for the idiomatic sentences (76%) compared to the literal sentences (52%). Our findings support the notion that the adjacency of co-occurring arguments plays an important role. The figurative meaning is preserved in syntactically modified idiomatic sentences as long as the verb and the idiomatic arguments are adjacent.

The adjacency constraint holds at least for German, a language with a very flexible sentence structure. We concur with Bargman and Sailer (2018), who claim that differences in

1 the syntactic constructions of a language have far-reaching consequences for the flexibility of
2 multiword expressions. We conclude that the syntactic properties of idioms should reflect the
3 syntactic peculiarities of the language in question, rendering German idioms syntactically
4 flexible, at least when the adjacency constraint is satisfied. This again supports the
5 assumption that the same syntactic processes rule idiomatic and literal sentences.
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11 *Conclusion*

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13 We explored the fundamental question of what factors influence whether syntactically
14 transformed idiomatic sentences keep their figurative meaning. Crucially, idiomatic sentences
15 seem to underlie the same processing mechanisms as literal sentences, since the effects of
16 voice and transitivity applied to both idiomatic and literal sentences. We focused on two
17 factors that have not been addressed so far: argument structure (i.e. verb transitivity) and
18 argument adjacency (i.e. the adjacency between the verb and the idiomatic arguments). When
19 it comes to the processing of syntactically transformed active and passive sentences, argument
20 adjacency seems to be more important for keeping the figurative meaning than argument
21 structure. Furthermore, the adjacency effect was more prominent for idiomatic than literal
22 sentences, indicating that the critical arguments are more strongly collocated in idiomatic than
23 in literal sentences. Future studies will be necessary to examine whether the effect of
24 argument adjacency overrules the effect of argument structure in passivized idioms in
25 languages other than German as well.
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Figure Captions

Figure 1. The effects of transitivity and voice (active/passive) on idiomatic and literal sentences in Experiment 1 (left panel) and Experiment 2 (right panel). Y-bars represent the standard error of the mean.

Figure 2. The effect of argument adjacency on idiomatic and literal sentences for Experiments 1 and 2. Y-bars represent the standard error of the mean.

Table 1
Examples of Idiomatic and Literal Sentence Pairs Holding the Same Transitive or Ditransitive Verb, Presented in Active and Passive Voice, and the Corresponding Verb Targets

Transitive Sentence Pairs		Target Verbs		
Idiomatic	Literal	Figurative	Associate	Unrelated
<i>Active</i>				
<i>Sie hat immer nach den Sternen gegriffen.</i>	<i>Das Mädchen hat nach den Bonbons gegriffen.</i>			
(W) She has always for the stars reached.	(W) The girl has for the sweets reached.			
(L) She always reached for the stars.	(L) The girl reached for the sweets.	<i>gegriffen</i>	<i>gelangt</i>	<i>gelebt/getastet</i>
(F) She tried to achieve something impossible.		(‘reached’)	(‘grabbed’)	(‘lived’/‘fumbled’)
<i>Passive</i>				
<i>Nach den Sternen wurde immer von ihr gegriffen.</i>	<i>Nach den Bonbons wurde von dem Mädchen gegriffen.</i>			

Ditransitive Sentence Pairs		Target Verbs		
Idiomatic	Literal	Figurative	Associate	Unrelated
<i>Active</i>				
<i>Sie hat dem Jungen den Kopf gewaschen.</i>	<i>Er hat der Tochter die Haare gewaschen.</i>			
(W) She has the boy the head washed.	(W) He has the daughter the hair washed.			
(L) She washed the boy’s head.	(L) He washed the daughter’s hair.	<i>gewaschen</i>	<i>gereinigt</i>	<i>gemessen/gebürstet</i>
(F) She gave the boy a piece of her mind.		(‘washed’)	(‘cleaned’)	(‘measured’/‘brushed’)
<i>Passive</i>				
<i>Dem Jungen wurde von ihr der Kopf gewaschen.</i>	<i>Der Tochter wurden von ihm die Haare gewaschen.</i>			

Note. Translations of a sentence into English are given: word-by-word (W), literal (L), and figurative (F).

Table 2

Stimulus Characteristics of the Verb Triplets that Complete the Idiomatic and Literal Sentences.

<i>Transitive</i>						
	Idiomatic			Literal		
	Figurative	Associate	Unrelated	Figurative	Associate	Unrelated
Example	<i>gegriffen</i>	<i>gelangt</i>	<i>gelebt</i>	<i>gegriffen</i>	<i>Gelangt</i>	<i>getastet</i>
Lemma Abs	1424 (2109)	635 (1588)	1510 (2460)	1424 (2109)	784 (1702)	1549 (2431)
Lemma MI	239 (354)	107 (267)	254 (413)	239 (354)	132 (286)	260 (408)
Syllables	1.7 (0.5)	1.3 (0.4)	1.5 (0.5)	1.7 (0.5)	1.6 (0.5)	1.6 (0.5)
Letters	8.3 (1.1)	7.6 (1.2)	8.3 (1.4)	8.3 (1.1)	8.3 (1.3)	7.9 (0.9)
<i>Ditransitive</i>						
	Idiomatic			Literal		
	Figurative	Associate	Unrelated	Figurative	Associate	Unrelated
Example	<i>gewaschen</i>	<i>gereinigt</i>	<i>gemessen</i>	<i>gewaschen</i>	<i>gereinigt</i>	<i>gebürstet</i>
Lemma Abs	792 (898)	994 (2219)	478 (552)	793 (898)	943 (2413)	293 (384)
Lemma ML	189 (395)	167 (373)	80 (93)	189 (395)	159 (405)	49 (64)
Syllables	1.6 (0.5)	1.5 (0.5)	1.3 (0.5)	1.6 (0.5)	1.5 (0.5)	1.5 (0.5)
Letters	8.2 (1.2)	8.2 (1.4)	7.7 (1.1)	8.2 (1.2)	8.3 (1.3)	7.9 (1.1)

Note. Lemma Abs = absolute mean lemma frequency; Lemma ML = mean lemma frequency per one million, both taken from CELEX (Baayen, Piepenbrock, & Van Rijn, 1993), Syllables = mean number of syllables, Letters = mean number of letters; SD in parentheses.

Table 3

Fixed Effects of the Predictors in the Linear Mixed-Effect Model for Response Latencies in Experiment 1.

	Estimate (ms)	95% CI	<i>t</i>-value	<i>p</i>
Intercept: literal, active, ditransitive, 6 letters	909	519 to 1299		
Sentence Type (idiomatic)	−115	−219 to −12	−2.18	.031
Voice (passive)	77	31 to 123	3.27	.001
Transitivity (transitive)	−19	−128 to 91	−0.34	.73
Target Length (per additional letter)	53	8 to 97	2.33	.022
Voice (passive) × Transitivity (transitive)	183	116 to 250	5.31	< .001

Note. CI = Confidence intervall

Table 4

Fixed Effects of the Predictors in the Multilevel Logistic Regression Model for the Completion Data of the Idiomatic Sentences in Experiment 1.

	Odds Ratio	95% CI	z-value	p
Intercept: active, ditransitive	5.4%*	3.0% to 9.7%		
Voice (passive)	0.95	0.57 to 1.58	−0.19	.85
Transitivity (transitive)	0.78	0.33 to 1.84	−0.57	.57
Voice (passive) x Transitivity (transitive)	3.42	1.66 to 7.07	3.29	.001

Note. *Baseline probability refers to the accuracy rate for active voice and ditransitive verbs.

Effects of passivation, transitivity and their interaction are expressed as odds ratios, along with their 95% confidence interval (CI).

Table 5. *Comparison of Argument Adjacency in Idiomatic and Literal Sentence Pairs across Experiments 1 and 2*

Experiment 1		
	Idiomatic	Literal
<i>Transitive</i>		
Active	Sie hat immer [nach den Sternen] [gegriffen].	Das Mädchen hat [nach den Bonbons] [gegriffen].
Passive	[Nach den Sternen] wurde immer von ihr [gegriffen].	[Nach den Bonbons] wurde von dem Mädchen [gegriffen].
<i>Ditransitive</i>		
Active	Sie hat dem Jungen [den Kopf] [gewaschen].	Er hat der Tochter [die Haare] [gewaschen].
Passive	Dem Jungen wurde von ihr [der Kopf] [gewaschen].	Der Tochter wurden von ihm [die Haare] [gewaschen].
Experiment 2		
	Idiomatic	Literal
<i>Transitive</i>		
Active	[Nach den Sternen] hat sie immer [gegriffen].	[Nach den Bonbons] hat das Mädchen [gegriffen].
Passive	Von ihr wurde immer [nach den Sternen] [gegriffen].	Von dem Mädchen wurde [nach den Bonbons] [gegriffen].
<i>Ditransitive</i>		
Active	[Den Kopf] hat sie dem Jungen [gewaschen].	[Die Haare] hat er der Tochter [gewaschen].
Passive	[Der Kopf] wurde dem Jungen von ihr [gewaschen].	[Die Haare] wurden der Tochter von ihm [gewaschen].

Note. The critical (idiomatic) arguments of the verb are in brackets.

Table 6

Fixed Effects of the Predictors in the Linear Mixed-Effect Model for Response Latencies in Experiment 2.

	Estimate (ms)	95% CI	<i>t</i> -value	<i>p</i>
Intercept: literal, active, ditransitive, 6 letters	963	510 to 1416		
Sentence (idiomatic)	−168	−341 to 6	−1.9	.06
Voice (passive)	80	10 to 150	2.25	.025
Transitivity (transitive)	−78	−259 to 102	−0.85	.39
Target Length (per additional letter)	71	19 to 123	2.67	.009
Sentence (i) × Voice (p)	72	−26 to 171	1.44	.15
Sentence (i) × Transitivity (t)	87	−167 to 342	0.67	.50
Voice (p) × Transitivity (t)	1	−102 to 103	0.02	.99
Sentence (i) × Voice (p) × Transitivity (t)	−210	−355 to −65	−2.84	.005

Note. CI = Confidence interval

Table 7

Fixed Effects of the Predictors in the Multilevel Logistic Regression Model for the Completion Data of the Idiomatic Sentences in Experiment 2.

	Odds Ratio	95% CI	z-value	p
Intercept: active, ditransitive	7.7%*	4.5% to 12.8%		
Voice (passive)	1.62	1.04 to 2.51	2.13	.033
Transitivity (transitive)	0.71	0.31 to 1.64	−0.80	.43
Voice (passive) x Transitivity (transitive)	0.58	0.28 to 1.19	−1.48	.14

Note. *Baseline probability refers to the accuracy rate for active voice and ditransitive

verbs. Effects of passivization, transitivity and their interaction are expressed as odds ratios, along with their 95% confidence interval.

Table 8

Fixed Effects of the Predictors in the Linear Mixed-Effect Model for Response Latencies in the Post-Hoc Analysis.

	Estimate (ms)	95% CI	<i>t</i>-value	<i>p</i>	AIC
<i>Analysis with Adjacency</i>					92631
Intercept: literal, active, adjacent, 6 letters	855	562 to 1148	5.71		
Sentence Type (idiomatic)	−127	−206 to −49	−3.16	.002	
Voice (passive)	115	90 to 139	9.09	< .001	
Adjacency (nonadjacent)	127	92 to 162	7.07	< .001	
Target Length (per additional letter)	61	27 to 95	3.57	< .001	
<i>Analysis with Transitivity</i>					92679
Intercept: literal, active, ditransitive, 6 letters	920	623 to 1217			
Sentence Type (idiomatic)	−127	−207 to −47	−3.12	.002	
Voice (passive)	116	91 to 141	9.14	< .001	
Transitivity (transitive)	−7	−87 to 73	−0.17	.86	
Target Length (per additional letter)	62	27 to 96	3.53	< .001	

Note. CI = Confidence interval

Figure 1

Figure 2

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