

## What Are You Thinking About Where? Syntactic Ambiguity between Abstract Arguments and Concrete Adjuncts in Hungarian, Modulated by Concreteness

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**Background.** The critical importance of lexical concreteness and embodied sensorimotor processes for language comprehension is often assumed to be beyond doubt. Hungarian grammar is unique in that it expresses certain verb arguments using spatial suffixes, which sometimes create ambiguity between literal spatial adjuncts and abstract verb arguments.

**Objective.** In the present study, our goal was to investigate the role and perhaps primacy of concrete spatial meaning when generating the abstract sense of arguments of mental verbs.

**Design.** Towards that end, we embedded ambiguous verb-noun constructs with both a possible locative adjunct reading (i.e. spatial, literal) and a verb argument reading (i.e. abstract, figurative), with a continuously varying preference for one or the other, in disambiguating sentence contexts. Using a self-paced reading paradigm, we measured reading times of verbs and sentence final nouns of the ambiguous constructs.

**Results.** We found no difference in the reaction times to verbs, which suggests that their argument frames were obligatorily activated regardless of sentential context. Nouns were read more slowly in the argument contexts, yet the slower pace was driven by constructs that had a preferred locative reading.

**Conclusion.** This pattern of results contradicts strong embodiment explanations, and can be better accounted for by dual coding theory. Our findings demonstrate the importance of studying the role of concreteness and metaphoricality in linguistic meaning construction in the context of syntax and sentence processing.

**Keywords:** sentence processing, embodiment, dual coding theory, arguments, spatial language, figurative language

## Introduction

In this paper we seek to bridge two distinct traditions of conceptualizing the construction of linguistic meaning. One of them looks at sentence parsing, centered around verbs and driven by expectancy, where verb arguments are thought to have primacy over external adjuncts (Kennison, 2002; Kintsch & Mangalath, 2011). The other relies on the dual coding theory of Paivio (1971, 2007) and embodiment (Lakoff & Johnson, 1999), both of which claim a superiority and primacy of concrete and perceptual meaning over abstract, purely linguistic meaning. Hungarian syntax allows the contrast of these two lines of research, due to the fact that in certain constructions spatial markers are not utilized in their concrete, literal, spatial meaning as adjuncts, but are exploited as grammatical arguments with an abstract, mentalistic meaning.

The idea that verbs play a central role in language representation and processing has been around for a rather long time. The peculiarity of verbs is related to their role of carrying sentential functions, thereby determining the grammatical role of noun phrases (NPs) for their various syntactic arguments. The seeds of this idea were already present in the logical model of predication proposed by Frege (1892/1984). Later it was raised again in different valence theories, first by Tesnière (1959), which introduced a chemical metaphor, where verbs are taken as complex stems that have different open slots, like the kernels of chemical compounds, and these slots are filled by NPs of various grammatical roles. A subsequent variant of the theory was case frames promoted by Fillmore (1968). The core of these ideas of sentence processing, detailed by various frame- and schema-based theories of understanding is, rather concisely, that sentence comprehension involves two basic stages (Schank, 1972; Kintsch, 1974):

1. Activate verb representations from long term memory storage, including their argument frames, together with the expected and likely arguments (such as Agent, Patient, Goal, Instrument, etc.).
2. Fill the argument slots with actual NPs from the incoming string.

Ensuing psycholinguistic experiments have indeed found facilitative effects between the processing of predicates and their arguments, which implied verb-based expectations towards certain types of arguments, be they called thematic roles or otherwise (Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995). For example, reading the verb *cut* facilitates the reading time of instrumental arguments (Kintsch, 1998; Kintsch & Mangalath, 2011). There have been intense discussions in the past century about how general (*cut* → instr) or how specific, lexical (*cut* → instr: knife) these expectations are. Other studies have shown that arguments are processed faster than adjuncts (e.g., Kennison, 2002), as adjuncts are optional, unlike arguments. The original goal of these theories was the detailed understanding of argument relations, which gave rise to the idea that Thematic Roles might be the key to the syntax-semantic interface in understanding (Carlson & Tanenhaus, 1988; Tanenhaus, Carlson, & Trueswell, 1989). However, the initial cognitively oriented theories were not particularly concerned with the exact grammatical markers employed by the system to assign argument roles to certain noun phrases.

Thematic Role assignment in sentence processing started to play a central role in syntax-based parsing theories (Ferreira & Clifton, 1986; Frazier & Fodor, 1978), with intense discussions regarding the automaticity and modularity issues. These considerations gradually raised the possible role of morphology, and its relation to semantic and cognitive issues concerning these expectation-based processes (for a review, see Pléh, Fekete, & Varga, 2017). Bornkessel and Schlesewsky (2006; Bornkessel-Schlesewsky et al., 2011) have run several behavioral, evoked potential, and imaging studies on sentence understanding in languages using different types of cues to argument roles (order, animacy, case marking, etc.). Independently of the specific cues, the Broca area always appeared to play an active role in assigning Thematic Roles. On the basis of these neuronal processing data, Bornkessel and Schlesewsky (2006) developed a full-fledged cross-linguistic theory of the temporal activation of verbal argument frames and the insertion of noun phrases into the slots as a second step.

In our work, we concentrate on oblique arguments of Hungarian verbs and capitalize on the fact that argument relations are coded by case markers in Hungarian (Kiefer, 1987, 2003). In such a language, argument processing and Thematic Role assignment are particularly closely tied with morphological processing. At the same time, there is a distinctive relation between morphological marking on NPs and the abstract/concrete semantic distinction. Most arguments of abstract, mental relational verbs (e.g., *to think*, *to remember*, *to fear*) are coded by spatial case markers, which otherwise denote locational relationships for verbs concerning physical position (e.g., *to put*, *to take*, *to go*). For example, the concrete, spatial relation in the Hungarian sentence *János elfordult a kutyától* (“John turned away from the dog”) is expressed by the ablative suffix *-tól/-től* (“from”). But the same suffix is used in an abstract sense in the sentence *János fél a kutyától* (“John is afraid of the dog”). This alternation of the physical and abstract sense of suffixes sometimes leads to ambiguities when a given NP could be either an abstract argument or a concrete adjunct. There has been much discussion about how to differentiate arguments from adjuncts in Hungarian (Alberti, Farkas, Szabó, 2015; Komlósy, 1994). Table 1 illustrates some of these intricacies (for more examples, see Pléh et al., 2017). Regarding language comprehension, these ambiguities also raise the question whether there is a preference for the concrete (adjunct), or for the abstract (argument) during sentence processing.

Table 1

*Varieties of the morphology of some argument frames in Hungarian*

Construct type	Example	Gloss
Unambiguous construct Abstract (mental) argument	Emlékszik a <b>fiúra</b> Haragszik a tanító <b>ra</b> . Készül a verseny <b>re</b> .	Remembers the boy-ON Angers the teacher-ON Prepares the race-ON
Ambiguous construct Abstract argument Concrete locative adjunct	Gondolkodik a lány <b>on</b> . Gondolkodik a hajó <b>n</b> .	Thinks girl-ON Thinks boat-ON

There are, of course, ambiguous argument frames in English as well. The sentence “John decided on the boat” can be interpreted either as John chose the boat or that he made his decision while being on the boat (Hornstein & Weinberg, 1981). In English these cases arise from a structural ambiguity based on the attachment height of the prepositional phrase (PP; in the cited example, the PP is “on the boat”). In Hungarian, however, such examples are related to the case suffixes of nouns. When a verb argument, which is syntactically closer to the predicate than a locative adverb, is expressed using a spatial metaphor, the figurative meaning becomes the part of the sentence structure that grammatically cannot be omitted. Since the argument is expressed using a suffix, grammatical complexity does not play a role in Hungarian when abstract figurative meaning has a syntactic function.

Some initial studies on argument structure processing in Hungarian have shown that the interaction between morphology and sentence comprehension is an intricate issue. Gervain and Pléh (2004) showed that prenominal verbs facilitated the processing of sentences (“Anna was thinking of the boat”), as opposed to sentences where nouns preceded verbs (“It was the boat Anna was thinking of”), which conforms to the idea that verbs activate their argument structure, and consequently, have a facilitative effect towards morphological endings coding for the arguments. Moreover, irrespective of word order, constructs with nouns referring to unambiguous concrete locative adjuncts were processed quickly, but processing slowed down when nouns referred to arguments that were unambiguously abstract, or ambiguous between the concrete locative and an abstract argument reading. Compare “Anna RUMINATED on the boat” versus “Anna RUMINATED on the problem”, where the locative meaning is excluded in the latter case due to the mentalistic meaning of the NP *the problem*. This finding in and of itself suggests that we quickly and obligatorily activate the concrete meaning of spatial markers, even for abstract arguments, just as embodiment would predict (Lakoff & Johnson, 1999). However, when examining the reaction times for verbs requiring arguments, most of them were read more slowly when they referred to ambiguous as opposed to unambiguous arguments, that is, when the semantics of the NP excluded a concrete spatial adjunct reading (as in the above example). This latter finding hints at just the opposite explanation: The abstract meaning could be activated independently of the concrete locative meaning, and the slowdown in the ambiguous conditions is due to a parallel activation of the two. The authors interpreted their findings in a sentence-processing model where a verb-based expectation arrow would obligatorily point towards the argument, and ambiguous arguments are read more slowly because of a parallel activation of the argument and a locative meaning. This is in line with dual coding (Paivio, 2007), in fact, which suggests that all words activate a purely linguistic, amodal code, whereas concrete words activate an *additional* imagistic code and this might happen in the case of ambiguous constructs. In sum, the reading times of the sentences as a whole and that of verbs with arguments produced an inconsistent pattern in terms of processing the abstract and concrete.

### ***The aims of the present study***

Gervain and Pléh (2004) reported verb reading times, on the one hand, that allowed for a dual coding interpretation, where the abstract argument structure would be the amodal, purely linguistic code, which is always activated, and if the morphological marker is a concrete, spatial suffix, there is an additional activation of the imagistic code for the literal meaning. Note that Paivio originally proposed the parallel activation as an explanation for the *faster* reaction times for concrete words. However, rather sophisticated and rigorously controlled experiments recently revealed a slower reaction time for concrete words (Kousta, Vigliocco, Vinson, Andrews, & Del Campo, 2011). The sentence-reading times of Gervain and Pléh (2004), on the other hand, suggest that locative adjuncts are processed quickly, and abstract arguments are processed as slowly as ambiguous ones. This finding implies that it is the activation of the concrete that can be carried out automatically, and it is the abstract meanings that are co-activated additionally, which is more consistent with embodied cognition (Lakoff & Johnson, 1999). The concrete should have primacy, and it is supposed to be obligatorily activated in order to provide content and conceptual structure to abstract concepts via metaphorical mappings (Lakoff & Johnson, 1980).

Experimental investigation of the basic proposals of embodiment are rather scarce. Even though a large number of studies have demonstrated the parallel activation of concrete and abstract meanings, the directionality of the effect, the primacy of the concrete, and the necessity of sensorimotor processes have not been backed by conclusive evidence. Forgács and colleagues (2015) found that even metaphors might not necessarily require imagistic and/or sensorimotor processes, even if they are constituted of concrete words, as reflected by the electrophysiological concreteness effect, which hinted that sometimes even concrete words might not require concrete senses.

We designed a Self-Paced Reading experiment, where we combined the processing of ambiguous morphological markers with a systematic manipulation of the abstract/concrete dimension to address the questions raised by the data of Gervain and Pléh (2004), and to further elucidate the primacy of the literal, concrete meaning in morphosyntactic aspects of sentence comprehension. To this end, we compared the processing of sentences ending in ambiguous verb-noun constructs that continuously varied in their preferred interpretation, leaning towards either an abstract argument or a spatial locative reading, all of which we embedded in two kinds of sentence contexts that allowed for either the locative or the argument reading. Although all sentences ended in concrete nouns and the same nouns appeared in both contexts, a concreteness effect could be expected, because based on electrophysiological studies, it seems to be driven not by lexical properties of single words but semantics of conceptual combination (Huang, Lee, & Federmeier, 2010) and sentence meaning (Holcomb, Kounios, Anderson, & West, 1999).

We intended to compare a number of possible temporal models, where processing advantage for the concrete or the abstract can be explored separately for verbs and nouns in locative and argument contexts. According to the conclusions of Gervain and Pléh (2004), all verbs should activate their full case frames in both conditions and irrespective of the preferred reading of the specific constructs. This



process should yield no difference in reading times across contexts, since the same constructs and the same verbs are employed.

The processing of the nouns coincides with the wrapping up of the whole sentence. Based on Gervain and Pléh's (2004) sentence results, if the activation of verb frames is obligatory, constructs should remain ambiguous irrespective of context, and then there should be no reading-time difference between argument and locative contexts. If frames are activated flexibly and the context sufficiently determines meaning by the reading of the constructs, argument contexts should be read more slowly than locative contexts, as reported by Gervain and Pléh (2004). This would conform to embodied accounts as well, since the slower pace for the abstract argument would suggest serial processing and obligatory sensorimotor simulation of the concrete spatial meaning (cf. Gallese & Lakoff, 2005; Lakoff & Johnson, 1999). Constructs in a locative context would be fast irrespective of their preferred reading; constructs in argument contexts should be slower, because of the necessary co-activation of the spatial meaning, but those with a preferred locative reading could have a processing advantage relative to those with a preferred argument reading because of a pre-activation of the spatial meaning.

Novel results regarding the concreteness effect (Kousta et al., 2011) would predict a slowdown for the concrete locative context, perhaps because of the parallel activation of the abstract meaning. A facilitated processing of nouns in argument contexts could also be due to activated verb frames (Fillmore, 1968), where slots have been opened for an abstract mentalistic meaning. Such a non-perceptual sense of a concrete noun that could refer to a physical place could be understood in terms of Paivio's (2007) purely linguistic code, and/or as emotional content, as suggested by Kousta and colleagues' (2011) abstractness effect, or even as the mentalistic content attributed via Theory of Mind functions, in propositional format, to the verb's agreement (e.g., "thinking about the ship"). It should be noted that a frequency-based explanation would also predict faster processing for mentalistic arguments (Kornai, Halácsy, Nagy, Trón, & Varga, 2006).

A third possible outcome is that we might find no difference, which would also be informative: It would indicate that because verb arguments are expressed in Hungarian via spatial morphological markers, their abstract meaning has been conventionalized to the extent that they are lexicalized, much like the meaning of idiomatic expressions, and they are not processed any differently from concrete, literal, spatial language (e.g., Forgács et al., 2012).

## **Methods**

### ***Participants***

In this study, 33 university students (4 female, age range: 18–22 years) participated for course credit. All of them were native speakers of Hungarian, had normal or corrected to normal vision, and had no history of neurological or psychiatric disorders. An additional 13 individuals were excluded from data analysis, because they did not retain at least five trials with correct responses per condition after outlier removal. Out of the 33 participants, only 25 were included in the analysis of sentence final target words for the same reason.

**Stimuli**

As a first step, 20 Hungarian ambiguous constructs were generated, where a spatial suffix allows for both a locative adjunct and a verb argument reading. Next, the ambiguous constructs like (1) were judged in a pretest by 51 raters who did not participate in the later experiment. They were rated on a 6-point Likert scale: Which meaning comes first, the abstract argument (2) or the concrete locative adjunct (3)?

- (1) *Gondolkodtam a hajón.*  
 “I was thinking the boatON.” Allows both locative and abstract reading.
- (2) *A hajóra gondoltam.*  
 “The boatON was I thinking.” Only abstract meaning allowed.
- (3) *A hajón voltam.*  
 “The boatON was I.” Only locative concrete meaning.

According to the results of the pretest, the ambiguous constructs covered the whole range of preference from the argument to the locative reading (Figure 1). Following the pretest, each of the 20 constructs was extended with two antecedent contexts that set up the sentence to clearly have either a locative or an argument reading. For example: “I had pleasant memories about it, that is why I was nostalgic about the excursion” vs. “I was at the place in my childhood, that is why I was nostalgic on the excursion.”

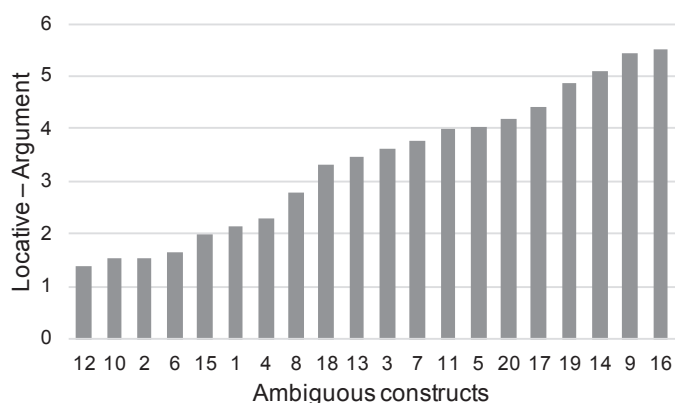


Figure 1. Results of the pretest for each ambiguous construct. The preferred reading of the constructs was relatively evenly distributed from the locative to the argument interpretation.

**Experimental procedure**

A Self-Paced Reading (SPR) paradigm (Just, Carpenter, & Woolley, 1982) was employed, where sentences were broken down to single words (nouns preceded by their articles) and presented individually until participants pressed a button, after which the next word appeared. Sentence final words were followed by a screen with an arrow pointing to the right, which was followed by test sentences concerning the ambiguous construct, identical with those of the pretest. The task of the participants was to verify whether the target sentence conformed to a locative adjunct reading or a verb agreement reading. Reaction times were registered for each word.

Every participant saw each construct only once, either in the locative or in the argument sentence context, but by employing two complementary lists, both variants were presented across participants.

## Results

Reaction time measures for the verb (the word before the final word) and the noun with the ambiguous suffix (sentence final word) were analyzed using linear mixed-effects modeling (Baayen, 2008; Baayen et al., 2008), via R (R Core Team, 2017) and the lme4 package (Bates, Maechler, Bolker, & Walker, 2015). Before data analysis we removed outlier data points 2 standard deviations away from the mean, separately for each participant, for responses faster than 200 ms and slower than 3000 ms, and items that were followed by an incorrect response. Participants were removed from later analyses if they did not have at least five correct responses per condition following outlier removal. Reaction times were log transformed for statistical analyses. The order of trials was included in the models as a fixed effect, since it significantly improved models of random effects only. Context (locative vs. argument) was entered in the models as a fixed effect, and the results of the Pretest with an interaction were added for nouns; random effects included items and participants as intercepts, and the latter incorporated random slopes for Context, to keep the random effect structure maximal (Barr, Levy, Scheepers, & Tily, 2013). Residual plots did not reveal obvious deviations from homoscedasticity or normality.



Figure 2. Violin plot of reading times (log reaction times) to verbs in the two contexts, where horizontal lines represent quartiles (A). Reading times to sentence final nouns are plotted against the preference for the argument or the locative reading of the ambiguous constructs according to the pretest (B), where fitted lines show the sentence context in which constructs were embedded. There was no reading-time difference for verbs, while sentence final nouns were read more slowly in argument contexts, but the effect was driven by constructs that had a preferred locative interpretation.



First, we analyzed reaction times for reading the verbs, but we found no significant effect of Condition [ $\beta = -0.01$ ,  $SE = 0.01$ ,  $F(1, 385) = 1.06$ ,  $p = .30$ ] (Figure 2A). Reaction times following sentence final nouns revealed a significant main effect of Context [ $\beta = -0.13$ ,  $SE = 0.06$ ,  $F(1, 292) = 4.68$ ,  $p = .031$ ], with nouns being read more slowly in the argument than in the locative context. There was also a significant interaction between Context and Pretest [ $\beta = 0.04$ ,  $SE = 0.02$ ,  $F(1, 293) = 4.51$ ,  $p = .035$ ], and when broken down by Context, a marginally significant modulation of reading times by preferred interpretation was revealed only for the argument context [ $\beta = -0.05$ ,  $SE = 0.03$ ,  $F(1, 128) = 3.46$ ,  $p = .065$ ] (Figure 2B).

## Discussion

In the present self-paced reading experiment, we presented participants with ambiguous constructs that could either have a concrete locative reading or an abstract verb argument reading. The constructs varied continuously with regards to their preferred reading according to a pretest, but they were embedded in sentences that provided a disambiguating context for one interpretation or the other. With this experimental design, we sought to exploit a unique syntactic ambiguity of Hungarian language, where the same morphological marker can indicate a verb argument or the locative of a sentence, in order to investigate the morphosyntactic processing of spatial suffixes. Specifically, we intended to investigate whether the concrete or the abstract sense takes precedence, and whether either of the two requires the parallel activation of the other during the course of processing, when a spatial suffix is utilized to mark the arguments of verbs.

The results revealed no difference in reading times of verbs in the two conditions. This finding suggests that verbs activate their case frames, as proposed by frame semantics (Fillmore, 1968) and reported by Gervain and Pléh (2004): The full argument structure does seem obligatorily activated, hence the lack of difference between the two conditions.

Nouns in argument contexts were processed slower than in locative contexts, which suggests, in line with embodied cognition (Lakoff & Johnson, 1999), that the concrete locative meaning is accessed quickly, but the abstract argument meaning is processed more slowly, perhaps because of the parallel activation of the literal spatial meaning. It also conforms to classical, facilitatory concreteness effects (Paivio, 2007), that is, shorter reaction times to concrete words than for abstract words, which raises the possibility that concrete words are processed faster in a concrete sense than in an abstract sense — even if abstract words are the fastest.

However, the significant crossover interaction between context and the preferred reading puts the results in an entirely different light. The preferred reading of ambiguous constructs modulated reading times significantly only in argument contexts, and they slowed down reaction times only for constructs with a preferred locative reading (and not for a preferred argument reading). This result contradicts embodiment, because it should be just the other way around: Reaction times should be slower for the argument reading due to the necessary activation of the spatial meaning of the suffix. There are two possible explanations. First, processing could be more context dependent: An ambiguous construct with a preferred locative reading could be read faster in a locative context and more slowly in an argu-

ment context — and vice versa — which could override concreteness. Second, the concrete sense could have been activated for constructs with a preferred concrete locative interpretation in the argument context, not for constructs with a preferred in the argument reading, and this could have been the reason for the overall slower processing. In other words, when the concrete meaning was primed, the abstract took no additional time to co-activate, perhaps because it had been activated already; but when the abstract meaning was primed, the concrete slowed processing down, which is in line with dual coding and the results of Kousta and colleagues (2011).

Taken together, these results suggest an intricate pattern of meaning activation and processing of ambiguous constructs with a spatial suffix that can have both a locative and an argument reading. Verb frames seem to be activated obligatorily, irrespective of context, and to be filled rapidly. The modulation of reaction times for nouns is better explained by the dual coding theory (Paivio, 2007), as reinterpreted by Kousta and colleagues (2011), than by embodiment. Further studies are necessary to confirm and refine our findings, which should be taken with a grain of salt, because of the low number of test sentences and high number of excluded participants. In conclusion, our results on the processing of ambiguous spatial suffixes indicate that the issues of concreteness and embodiment, as well as of grammatical metaphors, should be studied at the level of complex syntactic structures rather than solely at the level of individual words.

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