Perceptual Simulations of Temporal Uses of *In* and *On* in First and Second Language Processing

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Abstract

Prepositions in natural languages often appear to be governed by arbitrary conventionalized idiomatic uses (e.g., *I was born in May*, *I will see you on Sunday*). We present empirical evidence that such prepositional uses are not entirely arbitrary, as they activate image-schematic perceptual simulations during language processing.

In Experiment 1, native speakers of English were prompted to think about either the date or the month of their birthday, and then select one of four calendar diagrams, two foils, one flat calendar and one box-like calendar diagram designed to invoke perceptual simulations of support and containment respectively. There was a significant relationship between the question prompt (implicitly eliciting in or on) and the type of calendar chosen (containment or support). Thus, spatial schemas can be spontaneously activated when thinking about time even for non-literal, idiomatic uses.

Prepositional uses are notoriously difficult for English L2 learners. We surmised that improper prepositional uses may be linked to improper underlying perceptual simulations. This was confirmed in Experiment 2 where Japanese-speaking students of English were presented the same task as Experiment 1. Here, results indicate no relation between the date or month question and calendar choice. The experiments offer both theoretical and practical insights into how prepositions are processed by individuals with varying levels of language knowledge.

Keywords: Perceptual simulations; prepositions; second language learning; embodied cognition.

Introduction

Prepositions in natural languages often appear to be governed by arbitrary conventionalized idiomatic uses (e.g., Vandeloise, 1991). For example, native English speakers tend to take it for granted that one uses the preposition "on" to refer to the date on which one was born but one uses "in" to refer to the month in which one was born. These are of course conventional idiomatic uses that didn't have to be that way, and are "partly a matter of collocational habit" (Lindstromberg, 1998, p. 76). How are these idiomatic prepositional uses processed in the mind? On one account, locative prepositions such "in" and "on" lose their original literal semantic content of containment and support respectively, to take on grammatical characteristics, a process often described as grammaticalization (Hopper & Traugott, 1993). Thus, conventionalization over time would lead to semantic bleaching, such that the same prepositions – and the expressions they are embedded in – would be processed differently, whether they are used literally or idiomatically. Some evidence for a processing difference between literal (spatial) and idiomatic (temporal) uses of prepositions comes from a preliminary neuropsychological study. Kemmerer (2005) reports that brain-damaged subjects with left perisylvian lesions failed a test of knowledge of the temporal meanings of prepositions, but passed a test that assessed knowledge of the corresponding spatial meanings of the same prepositions, suggesting that the spatial and temporal meanings of prepositions are represented and processed independently of each other in the brains of adult speakers.

In the present study we considered an alternative hypothesis, namely that idiomatic prepositional uses in one's native language are not entirely arbitrary, as they may activate image-schematic perceptual simulations during language processing (Gibbs, 2006; Richardson, Spivey, Barsalou, & McRae, 2003; Zwaan, 2004). Spatial prepositions have been studied for artificial intelligence and automated translation (e.g., Andre et al., 1987; Retz-Schmidt, 1988), as well as for their complex mappings to various gradations in spatial relations (e.g., Bowerman & Choi, 2003; Coventry & Garrod, 2004) and image-schematic mental representations (Brugman & Lakoff, 1988). In particular, previous research has demonstrated our tendency to use spatial metaphors to help us understand time (e.g., Boroditsky, 2000). A wide variety of laboratory experiments have clearly demonstrated a role for embodied sensorimotor properties (or "perceptual simulations") in language processing (e.g., Barsalou, 1999; Bergen, Matlock, Lindsay, & Narayanan, 2007; Glenberg & Kaschak, 2002; Richardson et al., 2003). There is in fact a long history to embodied sensorimotor accounts of language that predates the recent spate of laboratory experiments. The field of cognitive linguistics has provided a number of spatial

descriptions of linguistic meanings in the form of "image schemas" (Gibbs & Colston, 1995; Lakoff, 1987; Langacker, 1987; Talmy, 1983). In particular, image schemas (two-dimensional layouts of idealized trajectors and landmarks) have proven especially illustrative for understanding the varied meanings of spatial prepositions (Brugman & Lakoff, 1988; Talmy, 1983; Tyler & Evans, 2003). Indeed, image schemas may be the quintessential generic form of the perceptual simulations that underlie the understanding of prepositions like over, on, and in.

Therefore, it may not be surprising to find that more specific properties of spatial relationships (such as the containment properties of "in", or the support properties of "on") become articulated in our perceptual simulations of the spatial metaphors we use for understanding time. Thus, although they are idiosyncratic, idiomatic uses of prepositions in English such as "I will see you on Thursday" may not be entirely arbitrary. Rather, they may involve perceptual simulations and/or image schemas based on the preposition being used (e.g., Brugman & Lakoff, 1988). We set out to test this hypothesis in Experiment 1.

Studying the processing of idiomatic prepositions in adult native speakers bears not only theoretical import, but also practical implications for learning a second language. Prepositional uses are recognized as notoriously difficult for English L2 learners to acquire, especially when their native language has no equivalent prepositions (e.g., in Korean, I May was born), or it possesses one single general preposition that collapses the meaning of two (e.g., in Japanese, ni subsumes both in and on), or it uses different prepositions (e.g., in Italian, I am going in Italy). Textbooks and materials for English second language (L2) learners emphasize the arbitrary nature of non-literal prepositional uses and have little to offer except the instruction to memorize either rules or examples. In Experiment 2, we hypothesized that Japanese L2 learners of English struggle with prepositional uses particularly because they cannot rely on the congruent perceptual simulations underlying such uses. In the Discussion section, we argue that an embodied account of sentence processing can potentially change instructional practices in second language education. We propose that if image-schematic mental representations are part and parcel of sentence processing, then language teaching curricula should benefit from taking advantage of that additional source of information in training second-language learners.

To summarize, the main goal of Experiments 1 and 2 was to investigate the influence of language on the activation of image schematic perceptual simulations. Perceptual simulation was operationally defined as the process of selecting a visually presented object, a calendar, congruent with a conventionally accepted response to a target question (date or month of birth). There were two experimental conditions (Date and Month), both of which incorporated four calendar diagrams designed to invoke perceptual simulations of support (Figure 1, item 1) or containment (Figure 1, item 2) or neutral filler items (Figure 1, items 3 and 4). Participants were first asked to think about the date or month of their birthday, then select one of the four calendars (in the experimental conditions). Japanese learners of English were additionally asked to respond to a sentence completion task eliciting the prepositions in or on. The following research questions were intended to explore the issues outlined above:

1. Do native speakers of English select calendar images whose perceptual simulation (container vs. support) is congruent with the unmentioned preposition (on or in) that is associated with the prompted question (date of birth or month of birth, respectively)?

2. Do Japanese speakers of English as a foreign language select calendar images whose perceptual simulation (containment vs. support) is congruent with the unmentioned preposition that is associated with the prompted question?

3. For the Japanese participants, does the presence or absence of an image influence the accuracy of responses in the sentence completion task?

4. Do those Japanese speakers who do select the congruent image respond with the correct English preposition?

5. In the case of Japanese participants, do higher proficiency speakers select the congruent primes more often than lower proficiency speakers?

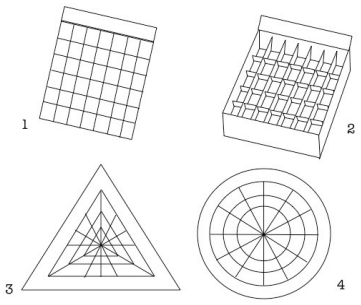

Figure 1. Calendar diagrams used in the date prompting condition, with the support image at the top-left.

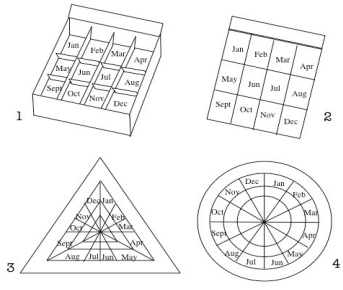

Figure 2. Calendar diagrams used in the month prompting condition, with the containment image at the top-left.

Experiment 1

Different languages use their spatial prepositions to carve up the various possible spatial relationships in a variety of ways. For example, where English uses "in" for containment spatial relationships, and "on" for support spatial relationships, Spanish and Japanese use a single preposition ("en" and "ni" respectively) for both containment and support (for discussion, see Coventry & Garrod, 2004). Moreover, where English collapses tightly-fitting containment and loosely-fitting containment into a single "in" category, Korean uses the prepositions "kkita" for the former (plus tight-fit support) and "nehta" for the latter (Bowerman & Choi, 2003; Choi & Bowerman, 1991; Mandler, 1992). Interestingly, English-learning infants can actually learn the tight-fit containment-or-support spatial category (referred to as "kkita" in Korean) when they are given a spoken novel word with which to label the image (Casasola, Bhagwat, & Burke, 2009). Thus, children's categorization of spatial relationships is influenced by the spatial prepositions they grow up with. Might even adults' real-time perceptual simulations of the language they read and hear be influenced by the preposition they use to describe an event (even if that preposition does not call for a literal meaning, but a purely idiomatic one)?

Method

Participants Fifty-one native English-speaking students were recruited at the University of Hawai'i at Mānoa.

Materials Since almost every spatial preposition in every language has a quite varied range of uses (e.g., Bowerman & Choi, 2003; Brugman & Lakoff, 1988; Haspelmath, 1997; Lindstromberg, 1998), the experiment focused on a particular idiomatic use of a spatial preposition, and examined the perceptual simulations that native speakers may be generating when they understand that particular idiom. Two sets of four calendar diagrams were designed to each include a single image that would invoke a perceptual simulation of support or containment. For instance, in the top-left corner of Figure 1, the diagram corresponds to the expression, born on [date] because it displays a spatial affordance of support, and the diagram in the top-left corner of Figure 2 corresponds to the expression, born in [month] because it displays a spatial affordance of containment. The circle and triangle diagrams are filler items intended to distract participants from figuring out the experimental manipulation and also to mitigate the potential influence of cultural bias due to the prototypicality of the flat calendar. The arrangement of the support and containment calendar diagrams was counterbalanced from left to right to avoid location preferences.

Procedure Randomly assigned participants were first prompted (without mentioning the prepositions "in" or "on") to think about the date or month of their birthday. Then one of two questions, "Which one of these calendars would you use to indicate the date [or, month] of your birth?" accompanied the calendar images depicted in Figure 1 or Figure 2 depending on the experimental condition. The calendar images were printed on a US letter sheet of paper. Participant choices were recorded by the experimenter.

Results

Congruence of perceptual simulations To address the above research questions in Experiments 1 and 2, Pearson's Chi-squared test with Yates' continuity correction was used to determine whether observed differences were statistically significant. An alpha level of .05 was set for each test we conducted. Experiment 1 was devised to answer the first research question, regarding the congruence of perceptual simulations in native speakers. The English native speakers in this study tended to select calendar images whose perceptual simulation was congruent with the preposition associated with the prompted question: 98% selected the support calendar when prompted with the date question, and 41% selected the container calendar when prompted with the month question. There was a significant relationship (χ^2 = 23.73, df = 1, $p < .001$) between the date or month question prompt (eliciting in or on) and the type of calendar chosen (containment or support). Thus, it appears that spatial schemas can be activated in one's native language when thinking about time even for idiomatic prepositional usages.

Experiment 2

A key topic of research in the area of spatial language is the cross-linguistic variation of how a given language's spatial prepositions partition and categorize various spatial relationships (Bowerman & Choi, 2003) – which brings us to the crux of the question addressed in Experiment 2. When second language (L2) learners make errors with spatial prepositions, what is the character of the perceptual simulations they generate (see also Coventry & Guijarro-Fuentes, 2008; Tyler & Evans, 2003)?

Method

Participants Eighty-two native Japanese-speaking undergraduate students enrolled in an English program at a private university in Tokyo, with a mean age of 20.5 years (SD = 5.4), voluntarily participated. On average, they had studied English for 8.8 years (SD = 2.6), and had spent a mean of 0.9 years abroad in English-speaking countries (SD = 2.1). When asked to rate their ability to use English on a scale of one to 10, their average rating was 4.5 (SD = 1.6).

Materials The same materials as Experiment 1 were used. Materials were remotely delivered via the Internet using a survey software (www.surveymonkey.com).

Procedure Participants were randomly assigned to an experimental condition or a control condition. In the experimental condition, participants were prompted with the statement that read "Think about the date [or, month] of your birthday" and then asked to select a calendar picture as

in Experiment 1. In the control condition, participants were prompted with the same statement but did not view the calendar pictures. Next all participants in both conditions were asked either, "What is the date of your birthday?" or "What is the month of your birthday?" and subsequently typed their answer in a blank field preceded by the stem, "I was born ...". Following this, they completed a 10-item cloze test (Brown, 1998) and filled out a questionnaire in Japanese, in part based on the Language Experience and Proficiency Questionnaire (Marian et al., 2007). All participants' responses (calendar choice, sentence completion, cloze items chosen, and responses to the questionnaire, were recorded by the survey software, and later downloaded for analysis by the experimenter.

Results

Congruence of perceptual simulations in L2 learners Our second question in this research project aimed to address the issue of congruence between prepositional use and elicited schemas with Japanese-speaking EFL learners. Here, in stark contrast to the findings in Experiment 1 with native English speakers, the results indicated no relation between the date or month question and calendar choice: 85% selected the support calendar when prompted with the date question, and 30% selected the container calendar when prompted with the month question ($\chi^2 = 0.92$, df = 1, p = .34). As might be expected, second language learners of English in this study did not show a tendency to select calendar images congruent with the time question posed to them. To directly compare native and non-native speakers, we collapsed the data from Experiment 1 and 2, and fitted a generalized log-linear model with three variables (Native Language, Prompt Question, Calendar Diagram). This saturated statistical model yielded a significant three-way interaction. To properly assess this significance, we followed a model simplification method (Crawley, 2005), by deleting the three-way interaction from the model, and checking whether a simpler model would lose explanatory power. Indeed the models differed (p = 0.025), so we retained the more complex model with the three-way interaction. The analyses confirmed that only the native English speakers show a tendency to select calendar diagrams consistent with the prompt question posed to them.

Calendar images and accuracy in L2 learners Our third research question asked whether the presence or absence of an image would influence English non-native speakers' accuracy of responses by way of a visual priming. Answers to the question, "What is the date of your birthday?" or "What is the month of your birthday?" were coded as either correct or incorrect for the experimental and control groups, depending on whether participants produced on or in. For the date question, neutral responses in which participants optionally deleted the preposition (e.g., *I was born Ø December 11th*) were excluded from the analysis (n = 12). To begin with, there was no apparent difference in the ability of participants assigned to the date and month to use prepositions correctly to answer the above question: 55% of participants in the date condition and 50% in the month condition used the correct preposition ($\chi^2 = 0.33$, df = 1, p = .57). Also, no significant interaction was found between the experimental and control group in terms of accuracy of response ($\chi^2 = 0.16$, df = 1, p = .69). Therefore, the presence or absence of the calendar images appeared not to influence accuracy of production. This is reasonable, given that participants were presented with a choice of four different calendars, and thus it is not apparent which of the four should have independently primed the a correct answer. These results appear to rule out an account in terms of conceptual priming, that is that conceptual representations based on a visual context prime other conceptual representations and preposition choices in production.

The possibility of an influence of calendar choice on accuracy was more closely examined through research question four, which probed whether participants who selected the congruent image provided an accurate response to the target question. Only 40% of them did ($\chi^2 = 1.2$, df = 1, p = .27), suggesting that for these participants, there is no relationship between image choice and accurate production**.**

Image choice and proficiency in L2 learners Finally, the fifth research question examined the likelihood of a relationship between image choice and proficiency level. After standard test item analysis techniques were applied to the cloze test, two items with low discrimination indices were excluded. Internal reliability was found to be .61 for the remaining eight items. We ran a logistic regression analysis, using a generalized linear model, with cloze test scores predicting congruency of calendar choice. Although the results were not significant under a two-tailed test (t = .56), there was a positive trend (slope coefficient = 0.08688) toward higher proficiency participants selecting images corresponding with the prepositional uses implied by the prompt question. This trend was confirmed using a chi-square analysis. A median cut-off point for high versus low proficiency was established and the relationship between choosing an image congruent with the prompt question and proficiency level (cloze test) was tested. Although these results were not significant ($\chi^2 = 2.13$, df = 1, p = .14), of those participants who did select the congruent image, a greater number were in the high proficiency group (19) than in the low proficiency group (11).

General Discussion

The present study looked at the susceptibility of individuals to forming spatial image schematic perceptual simulations when thinking about non-spatial metaphorical expressions. Although prompted to consider time, native speakers activated schemas for spatial prepositions, as shown by their selection of calendar images congruent with either containment or support. On the contrary, Japanese-speaking learners of English as a foreign language tended not to associate the spatial and temporal meanings of prepositions in this manner.

At present a number of questions remain unanswered about the role of perceptual simulations in second language learning. We suggest a few avenues for research that we are currently investigating, and that would shed light on whether it is possible to use image-schemas to assist L2 learning. First, further research should address to what extent L2 proficiency matters in activating perceptual simulations. The Japanese group we tested was comprised of low-to-intermediate level of English learners, who had mainly received formal schooling in Japan and little or no genuine immersion. It is possible that a comparison between this group and a more proficient group of L2 speakers will reveal a significant difference in the learners' susceptibility to perceptual simulations.

Follow-up studies will test for the reverse direction of the effect obtained in Experiment 1. That is, can priming a particular perceptual simulation influence the type of phrase that a speaker chooses to produce? Previous work has shown that participants' use of in and on is influenced by a variety of factors in the scene, including animacy of the Figure and the Ground, as well as the function and degree of concavity of the Ground, (Feist & Gentner, 1998; 2003). Future experiments could explore this use of in and on for idiomatic expressions that only metaphorically involve a spatial relation. For example, participants could be presented a single picture of either the box-like calendar (Fig. 2 top-left) with the month of their birthday included in its top portion or the flat calendar (Fig. 1 top-left) with the day of their birthday included in its top portion. They would then be instructed to report their date [or, month] of birth, and the measure is whether they use the preposition in or on. This type of manipulation would provide evidence regarding the bi-directionality of influences between perceptual simulations and language processing – showing not only that concepts can potentiate sensorimotor primitives (Mahon & Caramazza, 2008), but also that sensorimotor primitives can potentiate concepts. This is particularly relevant for L2 learning situations where the exposure to the statistical patterns of a specific idiom are less robust. Under such circumstances, the choices between seemingly-acceptable prepositions and perceptual simulations are more open-ended, and thus malleable by one another. Conversely, the extensive statistical exposure of English L1 speakers is expected to entrench their perceptual simulations, resulting in a more uni-directional influence. Evidence of perceptual malleability in L2 learners would then set the stage for other manipulations investigating the learnability of prepositions in L2. It is possible that perceptual experience guides learning and use. In fact, Celce-Murcia and Larsen-Freeman (1999) have claimed that "anchoring the meaning of prepositions in spatial relationships is the first step to helping students learn to deal with areas where the meaning is more abstract" (1999, p. 405). Activating the spatial meanings of these prepositions may give rise to simulations of containment and support that serve to anchor the temporal senses of in and on, respectively. New experiments can thus be devoted to an explicit investigation of a novel visual-context-oriented method of learning prepositions in a second language. Experiments that follow from this line of research can make explicit comparisons and tests between alternative second language teaching methods (e.g., Brown, 2006; Cook, 1996; Long & Doughty, 2009; Nunan, 1999), as well as explore additional prepositions. While language educators have often made suggestions regarding the use of images and other cognitively appropriate stimuli in teaching English prepositions (e.g., Celce-Murcia & Larsen-Freeman, 1999), their suggestions often lack rigorous empirical grounding. In particular, it remains for studies to incorporate both the use of pedagogic tasks involving pictures and the insights available from experimental cognitive linguistics in a single series of laboratory studies.

The two experiments presented in this study are merely the first steps in this research project, but they suggest that assisting the learning of subtle idiomatic use of spatial prepositions by adding visual aids that correspond to the image schemas (or perceptual simulations) associated with those prepositions might be a viable solution to helping L2 learners use language in a more native-like manner. By encouraging learners to think about the perceptual simulations that match the prepositions being used, language teaching materials and methods can make some of the more subtle and seemingly-arbitrary properties of a second language become more accessible to learners. Finally, such image-schema-based training methods could also help assess the effectiveness of motor simulations in the treatment of language disorders. For example, Kemmerer (2005) reports that brain-damaged subjects with left perisylvian lesions failed a test of knowledge of the temporal meanings of prepositions, but passed a test that assessed knowledge of the corresponding spatial meanings of the same prepositions. Training regimes that activate particular motor simulations might help reestablish the spatio-temporal links of prepositional usages in brain-damaged patients.

In closing, the two experiments reported here suggest that L1 and L2 speakers pay differential attention to image properties when spatial language is employed to talk about time. The results seem to support a conclusion consistent with the idea that image schemas may underlie perceptual simulations recruited during language processing. These experiments add to evidence that shows how spatial language directs attention as a function of particular entities and the interaction between them (Coventry, et al., 2010), which points to an explanation grounded in both cognitive linguistic theory and embodied sensorimotor accounts. Findings from future research may offer insight into the role of language experience.

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