

Metaphor priming in sentence production: Concrete pictures affect abstract language production



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ABSTRACT

People speak metaphorically about abstract concepts—for instance, a person can be “full of love” or “have a lot of love to give.” Over the past decade, research has begun to focus on how metaphors are processed during language comprehension. Much of this work suggests that understanding a metaphorical expression involves activating brain and body systems involved in perception and motor control. However, no research to date has asked whether the same is true while speakers **produce** language. We address this gap using a sentence production task. Its results demonstrate that visually activating a concrete source domain can trigger the use of metaphorical language drawn from that same concrete domain, even in sentences that are thematically unrelated to the primes, a **metaphorical priming effect**. This effect suggests that conceptual metaphors play a part in language production. It also shows that activation in the perceptual system that is not part of an intended message can nevertheless influence sentence formulation.

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1. Introduction

Much of human language is about abstract concepts like *love* that are invisible and intangible. Yet the words used to describe them often characterize them as though they were visible and tangible. It's conventional to say that one is *searching for love* or *finding satisfaction*, as though love and satisfaction were objects. But when we speak about abstract concepts concretely, are we also thinking about them concretely? Theoretical work in the Conceptual Metaphor framework (Lakoff, 1993; Lakoff & Johnson, 1980) argues that we are. If an abstract concept like LOVE can be systematically described as *exchanged*, *stolen*, or *shown* just like a physical object, then perhaps abstract concepts are not only described in terms of concrete concepts like physical objects; maybe these abstract target domains are also conceived of in terms of concrete source domains (as suggested by Johnson, 1987; Lakoff, 1987; Lakoff & Johnson, 1999; Lakoff & Turner, 1989). This might be a way in which the conceptual system grounds abstract concepts in terms of more perceptually, motorically, or physically concrete concepts.

Experimental research has begun to investigate whether and when people access such cross-domain mappings during language use, focusing mostly on reasoning and language comprehension. With respect to reasoning, Boroditsky (2000) found that subjects primed with an

object-moving spatial image (depicting objects moving in one direction along a line) were more likely to reason about time as a moving object, while perceiving an ego-moving scenario (where a person is moving relative to objects) made subjects more likely to reason about time as a stationary object that the experiencer moves past. In other words, activation of a concrete domain (in this case, SPACE) influences how people frame a metaphorically related abstract domain (TIME). Other experiments have shown that reasoning about crime policy is influenced by the metaphor used to describe it (Thibodeau & Boroditsky, 2013).

Sentence comprehension studies have similarly shown that processing utterances about abstract concepts subsequently activates representations of concrete source domains. Measures of source-domain activation include forced-choice and free-form drawing tasks (Richardson, Spivey, Edelman, & Naples, 2001), visual discrimination tasks (Richardson, Spivey, Barsalou, & McRae, 2003), sensibility judgments (Kaschak et al., 2005), categorical judgments (Santiago, Lupiáñez, Pérez, & Jesús Funes, 2007), and real or imagined motion (Gibbs, 2013). There's also work taking the reverse tack—showing that prior activation of source domain concepts influences subsequent abstract language comprehension (Boroditsky, 2001; Gibbs, 1992, 1994; Torralbo, Santiago, & Lupiáñez, 2006). For instance, physical engagement or experiences (in source domains) automatically influences comprehenders' interpretations of ambiguous sentences (Boroditsky & Ramscar, 2002), their preference for abstract near-synonyms (Tseng, Hu, Han, & Bergen, 2007), and processing speed for metaphorical

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language (Wilson & Gibbs, 2007). Moreover, some work shows that experiences of physical temperature affect interpersonal judgments (Williams & Bargh, 2008) and estimates of social proximity (Ijzerman & Semin, 2009). In sum, there are now numerous results from comprehension-oriented studies suggesting that (1) comprehending metaphorical language activates concrete source domain concepts, and that (2) activating particular concrete perceptual or motor knowledge affects subsequent reasoning and language comprehension about a metaphorically connected abstract domain.

However, questions remain about the exact processes engaged during metaphor comprehension and how to best account for variability in empirical results (e.g., McGlone, 2007; Steen, 2008; see Gibbs, 2013 for a recent review). For example, McGlone (2007) has suggested that conceptual mappings might only be activated in metalinguistic activities such as appropriateness rating tasks and has pointed out the need for a richer array of converging evidence, especially for the type of metaphor investigated in the study presented below, and Gibbs (2013) has likewise argued for the importance of studying metaphor across a range of language configurations. Other approaches to metaphor have argued that novel metaphors are processed differently from more conventionalized ones, suggesting an increasingly limited role for concrete source domains as a metaphor becomes more familiar, as well as revisiting the possibility that the comprehension of some metaphorical expressions involves prior or parallel activation of the literal interpretation of the expression (Bowdle & Gentner, 2005; Desai, Binder, Conant, Mano, & Seidenberg, 2011). Current psycholinguistic models draw heavily on the notion of parallel activation of alternatives (e.g., MacDonald, Pearlmutter, & Seidenberg, 1994), which further supports the possibility of simultaneous activation of literal and metaphorical interpretations during sentence comprehension. Under such a scenario, evidence for concrete source activation during metaphor comprehension could be linked to literal activations, instead of being a necessary component of the comprehension of the metaphorical meaning.

Investigating metaphor via language production provides a new way to assess theories of metaphor, expanding on data from introspection and comprehension paradigms. It is highly unlikely that a speaker producing a metaphorical expression is also activating a competing literal version of that expression. Nor should we find effects of concrete source activation on metaphor production if the metaphor has become so conventionalized that it is no longer associated with that source domain. Thus, if we find that exposure to a concrete source domain increases the likelihood of drawing from that domain to produce metaphorical language, we will have converging evidence for a causal role of conceptual metaphor in language use. No experimental research to date has addressed the question of conceptual metaphor activation in language production. Yet this is a critical issue if we want to understand the choices people make in using metaphor. Therefore, the work presented here takes a first step in exploring the role of concrete source domains in metaphor production.

Existing language production models view speakers as going through three primary processes: message formulation, grammatical encoding, and phonological encoding (Bock, 1995; Bock & Levelt, 1994; Ferreira & Slevc, 2007). Although specific production models propose different explanations of how non-linguistic concepts are connected to subsequent grammatical and phonological encoding processes, the underlying assumption across all models is that production begins when speakers formulate a prelinguistic version of (the beginning of) their intended message (Bock, 1995; Bock & Levelt, 1994; Bock & Loebell, 1990; Ferreira & Slevc, 2007; Levelt, 1989). In other words, existing production models primarily regard speakers' messages as emerging from their own intention. A rich body of literature has shown that the exact form that is produced can be influenced by previous experience, including a previously activated syntactic form (Bock, 1995; Pickering & Ferreira, 2008; Pickering & Garrod, 2013) or an entity in a to-be-described picture that is made more salient through attentional capture (e.g., Gleitman, January, Nappa, & Trueswell, 2007; van

de Velde, Meyer, & Konopka, 2014). These findings fit into a more general picture of production in which more accessible concepts and linguistic forms are favored. However, observed effects on the deeper content of the produced message have been limited to cases such as the construal of events with alternative perspective predicates, such as *chase* versus *flee*, in response to attentional capture (Gleitman et al., 2007) or the use of adjectives to mark contrasts made salient to the speaker in the discourse situation (Heller & Chambers, 2014; Lane, Groisman, & Ferreira, 2006). In the experiment described below, we asked whether the activation of concrete domain concepts influences the conceptualization phase of message formulation and thus ultimately affects the metaphorical description of abstract concepts in sentence production. Abstract concepts can often be expressed in a variety of ways, including different metaphorical means. For instance, LOVE can be described either as an object (it is something that can be *found*, *shared*, *shown*, etc.) or as a container (one can be *in love* or *fall out of love*). If mappings from concrete source domains to abstract target domains play a role in sentence production, then, we hypothesized, choice of a conceptual metaphor to describe an abstract target domain should be affected by prior activation of the relevant source domain concept.

We tested this through a production experiment. We first chose a set of 30 abstract concepts that can be described in terms of either of two concrete concepts: CONTAINMENT or POSSESSION. We then primed these concrete concepts through images. On each critical trial, participants saw two prime images, which both depicted a concrete configuration, either CONTAINMENT or POSSESSION. Critically, participants were not required to name or describe these pictures. Previous research on picture perception indicates that participants rapidly recognize the objects or scenes that are depicted in simple displays (Intraub, 1979; Potter, Staub, & O'Connor, 2004) but do not covertly name the pictured objects, even when their task is to click as quickly as possible on whichever object is named aloud (e.g., Dahan & Tanenhaus, 2005). We therefore reasoned that participants would activate the holistic concepts of CONTAINMENT or POSSESSION, but would not reliably activate linguistic descriptions of the pictures (although see below for further discussion of this possibility). Following the picture displays, participants were presented with a name (like *Mary*) and a word pertaining to an abstract domain that is metaphorically describable in terms of either CONTAINMENT or POSSESSION (like *love*). Participants had to formulate a sentence using the name and the abstract word. If abstract domains are not only talked about but also conceptualized in terms of concrete domains, then activating a specific concrete domain through picture perception should result in greater activation for the primed conceptual mapping, relative to alternative ways to conceive of the abstract domain. This should in turn increase the likelihood that people will subsequently activate and produce metaphorical language about the abstract concept using that same concrete source domain. In other words, we should observe metaphor priming.

2. Experiment

Participants saw concrete picture primes followed by linguistic prompts, and then quasi-spontaneously produced sentences using the linguistic prompts. In each trial of the experiment, subjects saw two consecutive pictures, both depicting either CONTAINMENT (e.g., an apple in a box), POSSESSION (e.g., a boy holding an apple), or neither relation (e.g., a boy using a computer; hereafter: "NEUTRAL" relations). The sequence of two pictures was followed by a linguistic prompt: a person's name and an abstract word (e.g., "Sally, trouble"). All of the abstract words could be metaphorically described in terms of multiple concrete source domains, critically including CONTAINMENT and POSSESSION, but were otherwise unrelated to the picture primes. Based on each linguistic prompt, subjects produced a simple sentence. We classified these resulting sentences as using CONTAINMENT metaphors, POSSESSION metaphors, or neither, using strictly linguistic

criteria described below (Lakoff & Johnson, 1980). We predicted that if metaphorical language that speakers produce about abstract concepts depends on the active use of a conceptual metaphor, then activating a concrete source domain (i.e., CONTAINMENT or POSSESSION) with the picture primes should increase the number of compatible metaphorical utterances. Perceiving containment pictures (e.g., an apple in a box) should increase activation of one's conceptual representation for CONTAINMENT, which should increase the likelihood of responses expressing CONTAINMENT (e.g., *Sally's life is full of trouble*) compared to NEUTRAL or POSSESSION responses. Likewise, activation of the POSSESSION domain by perceiving possession pictures (e.g., a boy holding an apple) should increase the use of POSSESSION responses (e.g., *Sally had trouble with her family*).

2.1. Materials

2.1.1. Picture materials

The picture stimuli were color drawings adapted from commercially available clip art or stimuli used by Griffin and Bock (2000). The experiment employed 180 pictures. Of these, 60 critical pictures (all described in Appendix 1) depicted three types of scene (20 each): (1) containment (e.g., a bird inside a cage, an apple within a box, or a bear in a bathtub), (2) possession (e.g., a hand holding a roll of film, a squirrel grasping a nut, or a runner carrying a flag), or (3) a neutral scene (e.g., flower in front of a house, a girl playing the piano, or a cat watching a moon). An additional 120 pictures that were NEUTRAL with respect to depictions of CONTAINMENT or POSSESSION served as fillers to hide the manipulation in the experiment. A norming study verified that each of the 60 critical pictures clearly conveyed CONTAINMENT, POSSESSION, or neither relation. This norming used 10 subjects who did not participate in the main experiment. Each picture was presented for 1200 ms. The subject then typed a description of the picture. Pictures were selected if eight or more subjects gave a response that matched the intended category, using the coding procedure described below for the main experiment.

2.1.2. Word materials

Each pair of pictures in the main experiment was followed by a linguistic prompt of a person's name and an abstract word. A corpus analysis using the British National Corpus verified that the abstract words were used in CONTAINMENT-related metaphorical expressions (e.g., *escape trouble*) or POSSESSION-related ones (e.g., *bring trouble*) with similar frequency. For each word, we collected 500 sentences from written language components of the corpus and 500 sentences from spoken language components, from various genres such as novels, journals, lectures, and speeches. Overall, the ratio of POSSESSION to CONTAINMENT utterances for the abstract words in the experimental items was 1.11:1. The complete list of prompts and the results of the corpus analysis can be found in Appendix 2.

2.2. Procedure

Participants were tested individually. Each completed a set of 3 practice trials, followed by 90 experimental trials. Each participant was presented with 30 critical trials and 60 filler trials, arranged in a different random order for each participant. On each trial, two different pictures were consecutively presented on a computer screen. For critical trials, the two pictures always depicted the same type of concept (i.e. two containment, two possession, or two neutral pictures). The first picture remained on the screen for 1200 ms, followed by a 500 ms inter-stimulus interval, then the second picture appeared for 1200 ms, followed by another 500 ms. The order of the pictures in a pair and their association to the subsequent linguistic prompt were held constant for each item. Finally, the two-word linguistic prompt was presented for 1500 ms. After the linguistic prompt disappeared, participants typed a simple sentence using the two words. Each response sentence was

recorded by the experimental software. Participants received no online feedback. The experiment was designed as a Latin square, so that the prime conditions for each linguistic prompt were distributed across three lists in a counterbalanced design. Therefore, each of the 30 critical linguistic prompts appeared in only one of the three conditions for each participant, counterbalanced across participants, and each participant received an equal number of prompts in each condition. The same number of participants (10) completed each list, and the entire experimental session took no longer than 30 min.

2.3. Participants

Thirty native speakers of American English who were students at the University of Hawaii participated in exchange for credit in introductory linguistics courses. All participants reported normal hearing and vision.

2.4. Data coding

A total of 900 critical responses were collected from the 30 subjects in the main experiment. Following the well-documented conceptual metaphorical framework proposed by Lakoff (1993) and Lakoff and Johnson (1980, 1999), the responses were assigned to one of the three categories: POSSESSION metaphor, CONTAINMENT metaphor, or OTHER (The full list of words that trigger categorization as POSSESSION or CONTAINMENT as well as representative sentences produced by participants are shown in Appendix 3.). A sentence was categorized as using a POSSESSION metaphor when the abstract word was described in terms most commonly applied to possession of a tangible object. This includes language about possession of objects, acquisition or loss of objects, searching for objects, and giving, receiving, and taking away objects. Some examples include *give him more trouble*, *steal her love*, *bring some questions*, and *the passion is gone*. A sentence was categorized as using a CONTAINMENT metaphor when the abstract word was described in terms most commonly applied to containers and containment relations. This includes language about bounded regions in space (e.g., *bottom*, *top*, and *sides*), change of location with respect to a container (e.g., *get in trouble* or *get out of trouble*), and of course containment itself (e.g. *be in love*). Finally, when the abstract word was described in a way that employed neither a CONTAINMENT nor a POSSESSION metaphor, as in *Sally seems to invite more trouble*, the response was categorized as OTHER. To encourage unconstrained and naturalistic sentence production, participants were not given syntactic categories to use for the abstract words. Therefore, in some cases, abstract words like 'trouble' were not used as independent nouns. These responses, such as *Sally is a trouble-maker* or *Kathy is troubled with a headache*, were classified as OTHER.

2.5. Results

As predicted, picture presentation increased the production of associated metaphorical sentences (see Fig. 1). Perceiving possession pictures (vs. neutral pictures) increased the production of POSSESSION responses by more than half (possession mean: 49.0%, vs. neutral mean: 30.3%), while containment pictures (vs. neutral pictures) more than doubled the production of CONTAINMENT responses (containment mean: 20.7% vs. neutral mean: 10.0%). We analyzed the results using mixed effects logistic regression, via the lmer program of the lme4 package (Bates, Maechler, & Bolker, 2011) in the R environment for statistical computing (R Development Core Team, 2011). Prime type was entered as a fixed factor with Possession as the default level, and intercepts for participants and items were included as random factors. (Adding random slopes did not significantly improve model fit.). We first ran a model on responses that were coded as POSSESSION responses against non-POSSESSION responses (i.e., CONTAINMENT and OTHER responses). Both the Possession-Containment contrast ($b = -0.65$, $SE = 0.18$, $z = -3.61$, $p < .0004$) and the Possession-Neutral contrast ($b = -0.95$, $SE = 0.18$, $z = -5.18$, $p < .0001$) were

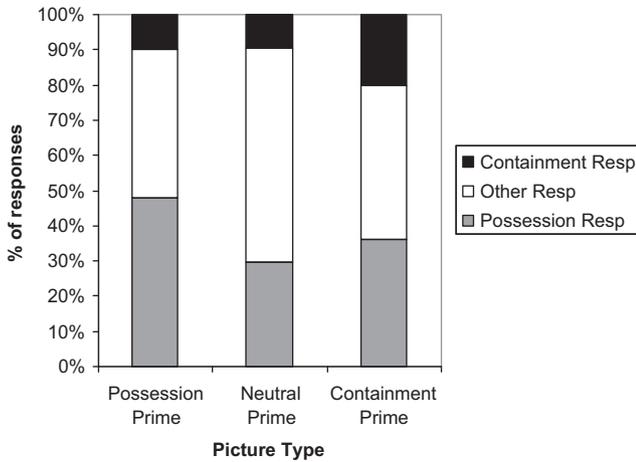


Fig. 1. Proportion of responses using CONTAINMENT, POSSESSION, or OTHER language in each of the three picture priming conditions.

revealed to be significant, and as expected, the Containment-Neutral contrast was not ($b = -0.32$, $SE = 0.19$, $z = -1.68$, $p < .09$). This indicates that POSSESSION responses increased significantly following Possession picture primes (49.0%) compared to Containment picture primes (36.0%) or Neutral picture primes (30.3%). Next, we ran a model on responses coded as CONTAINMENT against non-CONTAINMENT responses (i.e., POSSESSION and OTHER responses) as the dependent measure. The results again matched our predictions. For CONTAINMENT responses, no significant difference was found between the Possession prime condition (10.3%) and the Neutral prime condition (10.0%), $p > .92$. However, the Possession-Containment contrast reached significance ($b = 1.13$, $SE = 0.27$, $z = 4.10$, $p < .0001$), as did the Containment-Neutral contrast ($b = -1.12$, $SE = 0.28$, $z = -4.21$, $p < .0001$). There was a significant increase in CONTAINMENT responses from the Possession prime and Neutral Prime conditions to the Containment prime condition (20.7%).

3. Exploratory analysis of the role of lexical priming

The results reported above indicate an effect of picture primes on the use of metaphorical language in subsequently produced sentences. The experiment was designed to measure the extent to which activating a concrete source domain would lead to metaphorical language about an abstract target domain that used that same, primed source domain: metaphor priming. However, there is another process that could in principle have produced the same results: lexical priming. Perceiving the image could have activated specific words that were subsequently used in sentence production. For instance, seeing an image of a puppy in a box could have activated the word *in*, which might have then been more likely to be reused in the sentence production task. This alternative explanation rests on linguistic encoding of the picture primes. Subjects who perceive a picture might form implicit linguistic descriptions, such as *an apple in a box*, even though they were not asked to describe the pictures. The particular phrase structure or lexical items included in that description could then influence the target sentence.

While intuitive, there are reasons to be skeptical of this alternate explanation. For one, nothing in the experiment prompted participants to encode the images linguistically—there was no picture comprehension, recall, naming, or description task that might encourage participants to attend to the pictures or to implicitly encode them verbally. Second, even if participants automatically put the pictured object into words in the 1200 ms that the image was on the screen, these words seem more likely to have been nouns describing the concrete objects presented (e.g., *apple* or *box*) than prepositions (e.g., *in*) describing the abstract relationship that holds between the objects. Third, the images were always thematically unrelated to the subsequently presented words, so

there was no reason for participants to believe attending to the pictures afforded them an advantage in the production task. Fourth, implicit naming is not an automatic consequence of picture viewing (Intraub, 1979; Potter et al., 2004). And finally, previous work investigating concrete source activation on metaphor comprehension did not find any evidence that potential lexical activation for concrete primes facilitated comprehension times for related metaphorical stimuli (Wilson & Gibbs, 2007). All of this makes it unlikely that people would automatically encode linguistic descriptions of the abstract relational structures of pictures we presented them with.

However, in order to examine in a systematic way whether and to what extent linguistic priming could be responsible for the observed effects, we conducted a post hoc analysis excluding any cases that could potentially arise from lexical priming by conservatively recoding them as OTHER. To determine which relational terms about CONTAINMENT or POSSESSION participants might be robustly generated on the basis of the priming images, we looked at the picture descriptions from the 10 participants in the norming study (see the description of picture materials above). Relational terms in their responses were *in*, *inside*, *full (of)*, and *filled (with)* for containment pictures and *have*, *hold*, *with*, *carry*, *pick*, *grab*, and *drag* for possession pictures. We took these as words that participants could implicitly activate when perceiving the pictures. In a post-hoc analysis of the main experimental results, we recoded responses in the main production task according to whether they contained one of these potentially primed words or not. The subset of responses with potentially primed words included 102 CONTAINMENT responses (across the three picture conditions, i.e. out of the 900 total responses), and 234 POSSESSION responses (across the three conditions). The set without those words included only 21 CONTAINMENT responses, but 112 POSSESSION responses (Appendix 3). We expected to see the same effect in each subset that we found for the aggregate results—an increase in metaphorical POSSESSION language following possession images and in metaphorical CONTAINMENT language following containment pictures. This would suggest that the metaphorical priming effect occurs not only when lexical priming is a possible explanation but also when it is not.

Among the subset of responses that included words potentially describing the priming images (with all remaining responses coded as OTHER), containment and possession pictures increased CONTAINMENT and POSSESSION metaphors respectively, just as they did in the original, aggregate analysis. Mixed effects logistic regression models were constructed with Prime Type as a fixed factor and participants and items as random factors, in the same way as in the aggregate analysis. We first ran the model by setting the dependent measure as responses that were labeled as POSSESSION responses and included words potentially describing the priming images (i.e., lexically-primed POSSESSION responses) versus all other responses. Both the Possession-Containment contrast and the Possession-Neutral contrast were significant, indicating that potentially lexically-primed POSSESSION responses were more likely to be produced in the Possession prime condition than in the Containment prime condition (31.3% vs. 24.0% of all responses in the respective conditions, $b = -0.44$, $SE = 0.20$, $z = -2.22$, $p < .03$) or the neutral prime condition (22.7%, $b = -0.52$, $SE = 0.20$, $z = -2.63$, $p < .009$). As expected, the Containment-Neutral contrast was not significant, $p > .66$. Likewise, we ran the model by taking responses that were labeled as CONTAINMENT responses and included words potentially describing the priming images (i.e., lexically-primed CONTAINMENT responses) or not (e.g., the rest of the responses) as the dependent measure. Mirroring the aggregate analysis, there was no significant difference for the Possession prime (9.3%) versus the Neutral prime condition (9.0%), $p > .93$, and significantly more CONTAINMENT responses in the Containment prime condition (15.7%) than the Possession prime condition ($b = 0.82$, $SE = 0.29$, $z = 2.82$, $p < .005$) or in the Neutral prime condition ($b = -0.87$, $SE = 0.30$, $z = -2.93$, $p < .004$).

Critically, however, the same patterns were also found in the other subset of responses—those not containing a word potentially describing

the images. In the model taking POSSESSION responses as the dependent measure and contrasting responses that did not contain a word potentially describing the images versus all other responses, there was a significant effect of the Possession-Containment contrast (17.7% vs. 12.0% of all responses in the respective conditions, $b = -0.50$, $SE = 0.25$, $z = -2.03$, $p = .04$) and the Possession-Neutral contrast (17.7% vs. 7.7%, $b = -1.06$, $SE = 0.28$, $z = -3.76$, $p = .0002$), as well as a marginal effect of the Containment-Neutral contrast ($b = -0.58$, $SE = 0.30$, $z = -1.91$, $p < .06$). Among these 112 responses, 53 occurred in the Possession picture condition. For CONTAINMENT responses that did not contain a word potentially describing the images, the results once again showed a significant effect for the Possession-Containment contrast (1.0% vs. 5.0%, $b = 1.98$, $SE = 0.72$, $z = 2.75$, $p < .007$) and the Containment-Neutral contrast (5.0% vs. 1.0%, $b = -2.09$, $SE = 0.76$, $z = -2.76$, $p < .006$). Although there were only 21 CONTAINMENT responses in the complement set, 15 of them were produced in the Containment picture condition. As in the previous analyses for CONTAINMENT, no significant difference was observed for Possession-Neutral contrast (1.0% vs. 1.0%, $p > .997$). Note that the subset analysis recoded any response in the main experiment that potentially included containment or possession language. Therefore, if the tendency for CONTAINMENT or POSSESSION responses was enhanced by the use of a pair of picture primes (versus a single prime), the subset analysis has still addressed potential lexical priming.

In short, the significant effect of picture type remained even after we recoded responses using words that could potentially have been used to describe the priming images, and could therefore potentially be explained by lexical priming. One could of course postulate a more complex sequence of priming, in which participants first linguistically encoded relations in the pictures, which then activated other associated relational words through links unrelated to the relevant conceptual domains (e.g., *in* primes *out*, or *have* primes *lost*, but not via any semantic or conceptual connections that involve CONTAINMENT or POSSESSION). While we cannot rule this out as an explanation for the priming we found, the weight of evidence suggests that at least some degree of conceptual activation is part of the metaphor priming effect.

4. Discussion

This study investigated whether activation of a specific concrete concept influences the subsequent production of metaphorical sentences about metaphorically related abstract concepts. For both Containment and Possession picture primes, the number of domain-related metaphorical sentences increased compared to the Neutral condition. This was true, as we showed through a post-hoc analysis, even after excluding responses using words that could have described the preceding pictures. Activating a particular concrete domain made speakers more likely to formulate language about abstract concepts in terms of that concrete domain. This is consistent with the claim that conceptual metaphor is an active component of linguistic cognition (Lakoff & Johnson, 1980). This argument has received previous experimental support from studies of language comprehension (Boroditsky, 2001; Thibodeau & Boroditsky, 2013). Our results expand on this picture to show that in language production, too, perceptual experiences can bias the choice of a particular conceptual frame used for linguistic expression in the form of the specific language that is produced. Of course, as a first step in examining source domain priming effects in metaphor production, our production task made use of a highly controlled experimental paradigm. Further work will be necessary to see whether the results reported here remain across a wider set of experiments and language situations. For example, the experiment presented above made use of a pair of picture primes. A source domain will need sufficiently strong activation to produce a priming effect, and so it may be the case that these results only generalize to other situations with strong instantiation of the source domain concept. Further research will be necessary to see if more subtle manipulations, such a

design with just a single picture prime, would elicit similar results. We would also like to see this work extended to tests with more abstract containment/possession images, with source domain activation via non-pictorial means, and more natural speech situations.¹ Nevertheless, these results are consistent with the idea that people also automatically access metaphorical mappings while producing language about abstract concepts, and we believe that the current results provide preliminary evidence that will be helpful in encouraging additional research.

Another implication of these findings relates to the use of sensory-motor systems in metaphor comprehension. Neuroimaging research has shown that understanding not only literal action sentences (e.g., *grasp the flowers*) but also conceptual metaphors involving action words (e.g., *grasped the idea*) activates sensory-motor areas that are responsible for perception and for action planning (Boulenger, Hauk, & Pulvermüller, 2009; Desai et al., 2011). Viewing an image of containment or possession may activate sensory resources that are also involved in selection of an appropriate metaphorical mapping for a given target domain.

A final implication of the metaphor priming results we've reported relates to mechanisms of speech production. Some psycholinguistic work on the human language production system describes the message level as a representation of an abstract nonlinguistic code, capturing the speaker's intended ideas and providing the raw material for the next process, grammatical encoding (Bock, 1995). In other words, the message is defined as an intentional representation that influences subsequent processes of sentence production. However, Lane et al. (2006) have shown that grammatical encoding processes include not only conceptual features that make up the intended message, but also features that are not intended to be expressed and yet are accessible to the speaker. Our metaphor priming results show something similar. When concepts that are not components of the message (like containment or possession) are activated, they can influence subsequent speech production. Even if some of the metaphor priming we've observed is driven by linguistic encoding of the pictures, or by the experiment-specific situation of receiving a pair of abstractly related images, the effects nevertheless show that a message can be unintentionally framed by the activation state of otherwise irrelevant parts of the cognitive system. Admittedly, we observed this effect under laboratory conditions, in which participants did not have a particular message they needed to convey: the task simply demanded that they produce a sentence. Nevertheless, by showing that conceptual domain effects are possible, these results pave the way for more ecologically valid studies of the role of irrelevant active concepts in sentence production.

In summary, our results are consistent with a model in which both intentionally and unintentionally activated conceptual components can shape the production of sentences, including activated concepts such as the concrete source domains tested here. In the case of abstract language, an activated concrete domain can have measurable effects on the ultimate form of the message that is produced. This effect thus provides further evidence for the importance in language production and comprehension of the rich environment, including the cognitive context, in which a linguistic act takes place.

Appendix 1. Descriptions of pictures

Possession pictures:

1. a bear holding a pen
2. a hand holding cards
3. a man holding a can of soda
4. a man holding a mug
5. two old ladies hugging
6. an animal holding a flag
7. a father carrying his baby

¹ We thank an anonymous reviewer for suggesting this idea.

8. a woman on a chair who is holding a big apple
9. a woman about to throw a basketball
10. a woman holding many things in her hands
11. two hands shaking
12. a boy dragging a stuffed bear
13. a girl holding a skateboard
14. a hand grabbing money
15. fingers picking up a film case
16. a woman holding money and a man holding a surfboard.
17. an athlete hoisting a flag
18. a man using chopsticks
19. a small boy holding a toy
20. two rabbits eating apples

Containment pictures:

1. a man in a car
2. a bear taking a bath
3. a bird in a bird house
4. cigars in a box
5. a small dog in a basket
6. various small objects in a box
7. two small boys playing in a box
8. fish in a fish tank
9. coins in a purse
10. a monkey in an airplane
11. a baby kangaroo in its mother's pouch
12. food in a fridge
13. money in a bag
14. a small animal in a cup
15. a small boy sleeping in a bed
16. a small girl in a car
17. many eggs in a basket
18. pencils in a pencil holder
19. gifts in a Christmas stocking
20. a bird in a cage

Appendix 2. For each abstract target word, the raw number of tokens out of 500 that were analyzed as drawing from the POSSESSION domain or the CONTAINMENT domain. (See the main text for the linguistic criteria used for domain analysis.)

Target word	POSSESSION domain tokens	CONTAINMENT domain tokens
1 Health	18	24
2 Day	44	76
3 Dream	46	40
4 Relationship	53	75
5 Heart	55	88
6 Effort	57	100
7 Time	69	42
8 Speech	70	108
9 Love	75	127
10 Issue	80	90
11 Sleep	83	70
12 Attempt	86	142
13 Question	88	96
14 Business	94	130
15 Memory	94	137
16 Spirit	100	130
17 Trouble	105	215
18 Attitude	110	98
19 Authority	110	42
20 Pain	113	37
21 Interest	118	84
22 Situation	120	178
23 Control	130	124
24 Affair	134	130
25 Place	140	210
26 Capacity	148	116
27 Sense	149	479

(continued)

Target word	POSSESSION domain tokens	CONTAINMENT domain tokens
28 Position	152	248
29 Power	210	192
30 Effect	216	150
Average	102.2	125.9

Appendix 3. The metaphorical properties used to categorize responses as POSSESSION or CONTAINMENT, along with representative examples produced by participants in the main experiment. Examples that avoided language used to describe the prime pictures in the norming study (see Section 3) are indicated with an asterisk

CONTAINMENT metaphors

1. Containment itself (e.g., *be in, within, inside*)
 - Joe *was in* an awful attitude.
 - *Inside* of his heart, all he thinks about is money and himself.
2. Bounded regions in space (e.g., *bottom, top, sides*)
3. Capacity of bounded regions (e.g., *size, depth*)
4. Manner of locational changes into bounded regions (e.g., *motion verb + in/into*)
 - Bobbie *fell in* love working in the potato factory.
 - Cindy always *meddles in* my business.
 - Bobbie *stood in* question, not understanding what was going on.
 - *What trouble has Cindy *gotten* herself *into* now?
 - *Cindy likes to *butt into* people's business.
 - *Kathryn was *running into* trouble.
5. Manner of locational changes out of bounded regions (e.g., *motion/be verb + out of*)
 - *Lilly is running out of time.
 - *Mary got out of the relationship with the pilot.
 - *Lilly said this emergent situation is out of control.
6. Bounded regions containing substance (e.g., *fill, full of, overflow*)
 - Nick's heart *is filled with* money.
 - Nick said time *is full of* shit.

POSSESSION metaphors

1. Possession of objects (e.g., *have, own, hold, keep, carry, bring, with*)
 - Bobby *has* a lot of interest.
 - *Eric *owns* a business.
 - Cindy *held* her spirits long enough to finish the race.
 - *Bobbie *keeps* a good relationship with his girlfriend.
 - Lilly *carries* a good heart.
2. Transfer of objects (e.g., *give, take, receive, move*)
 - *The key is to *give* a good effect with people.
 - *Ben *received* a powerful position at work.
 - *Victoria didn't *take* authority well.
3. Acquisition or loss of objects (e.g., *get, steal, gain, acquire, loose, lack, find, exchange, borrow, lend, return*)
 - *Angela's heart had been *stolen* by Joe.
 - *Barbara *got* some issues because she always smokes cigars when her bird is around.
 - *Power was *gained* by Joe.
 - *Lilly *lost* her magical powers.
 - *Laura *found* power in gambling.
 - *Tony *lacks* good sense.
4. Searching for objects (e.g., *search, seek, look for*)
5. Desire for objects (e.g., *need, want, long for, desire, crave, request*)
 - *Lilly *needs* some control.
 - *Joe *wants* power.
6. Showing objects (e.g., *show, present, reveal, see*)

- *Eric shows school spirit at the football games.
 - *Nick revealed his big heart when he donated money to the children's hospital.
 - *Laura saw the effect.
 - *Barbara presented a speech.
7. Physical manipulation of objects (e.g., *create, make, break, destroy, fix, repair*)
- *Key to designing home is to *create* a homely effect.
 - *Eric *made* an attempt at humor again.
 - *Laura needs to *fix* her attitudes because she's not so friendly when she gambles.
 - *Joe's efforts were *destroyed* by his grandparents.
 - *Cindy is so strong, her spirit could never be *broken*.
8. Physical use of objects (e.g., *use, put, attach, lift, raise, pick, grab, drag, throw, leave, abandon*)
- *Joe *puts* effort into reloading film.
 - *Lilly's heart was *attached* to her son and husband who is on a business trip.
 - *Mary tends to *abandon* relationships when they get too complicated.
 - *Joseph *used* his authority over the children to get more toys.
 - *Eric's spirit was *lifted up* by a hug.
 - *Cindy's spirit was *raised* when she saw her two children getting along.
9. Value of objects (e.g., *afford, waste, spend, save, share, worth, cheap, expensive, valuable*)
- *Kathy's effort was *wasted*.
 - *Joe *spent* the day at his grandparents' house.

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