COGNITIVE SCIENCE
A Multidisciplinary Journal

Cognitive Science 35 (2011) 156–170

ISSN: 0364-0213 print / 1551-6709 online
DOI: 10.1111/j.1551-6709.2010.01150.x

Structural Priming as Structure-Mapping: Children Use Analogies From Previous Utterances to Guide Sentence Production

Micah B. Goldwater,[a] Marc T. Tomlinson,[b] Catharine H. Echols,[b] Bradley C. Love[b]

[a]*Department of Psychology, Northwestern University*
[b]*Department of Psychology, University of Texas at Austin*

Received 31 March 2009; received in revised form 10 March 2010; accepted 11 March 2010

Abstract

What mechanisms underlie children's language production? Structural priming—the repetition of sentence structure across utterances—is an important measure of the developing production system. We propose its mechanism in children is the same as may underlie analogical reasoning: structure-mapping. Under this view, structural priming is the result of making an analogy between utterances, such that children map semantic and syntactic structure from previous to future utterances. Because the ability to map relationally complex structures develops with age, younger children are less successful than older children at mapping both semantic and syntactic relations. Consistent with this account, 4-year-old children showed priming only of semantic relations when surface similarity across utterances was limited, whereas 5-year-olds showed priming of both semantic and syntactic structure regardless of shared surface similarity. The priming of semantic structure without syntactic structure is uniquely predicted by the structure-mapping account because others have interpreted structural priming as a reflection of developing syntactic knowledge.

Keywords: Analogy; Language acquisition; Language production; Structural priming

1. Introduction

The priming of sentence structure, known as *structural priming*, has recently seen a surge of interest (e.g., Bock & Griffin, 2000; Chang, Dell, & Bock, 2006; Kaschak & Borreggine, 2008; Pickering & Garrod, 2004). Structural priming is analogous to other

Correspondence should be sent to Micah B. Goldwater, Department of Psychology, Northwestern University, 2029 Sheridan Road, Evanston, IL 60208. E-mail: micahbg@gmail.com

instances of priming wherein primed material is easier to access, in that primed grammatical constructions become more likely to be repeated across utterances. Structural priming has been used to investigate mature linguistic representations in adults (e.g., Bock, 1986) and developing representations in children (e.g., Savage, Lieven, Theakston, & Tomasello, 2003, 2006).

In addition to providing psycholinguists an experimental tool, structural priming may serve important functions for language users and learners. Structural priming has been proposed as a mechanism by which coordination and fluency in conversation is achieved (Pickering & Garrod, 2004). At a longer time scale, persistent effects of structural priming suggest that it is a mechanism by which long-term learning is achieved (Chang et al., 2006). Here, we present evidence that structural priming is a result of making an analogy between utterances.

For an example of structural priming, consider that a scene of a father sharing cake with his son could be described with the double object dative (DO) construction, for example, ''the father is giving his son cake,'' or with the prepositional phrase dative (PP) construction, for example, ''the father is giving cake to his son.'' When an experimenter describes this scene (the *prime* scene) with the DO (the *prime* utterance), then presents the next scene (the *target* scene) depicting a girl telling her friends a story, a strong form of structural priming would be shown by the increased likelihood that the participant describes the scene (the *target* utterance) with the DO and not the PP. However, as we will argue, priming both highly related dative constructions together relative to unrelated constructions, for example, the transitive as in ''The father and son are sharing the cake'' could represent a weaker form of structural priming.

In this paper, we examine the development of structural priming in children. Structural priming is a popular tool for exploring the development of linguistic representations (e.g., Bencini & Valian, 2008; Savage et al., 2003, 2006; Shimpi, Gamez, Huttenlocher, & Vasilyeva, 2007; Song & Fisher, 2004; Thothathiri & Snedeker, 2008). However, despite strong interest from developmental quarters, the answers to key theoretical questions, such as the mechanisms that produce the observed priming, remain unclear.

We suggest that structural priming is rooted in analogies between prime and target scenes and utterances. At its core, analogy is about drawing parallels and making inferences based on these parallels. Appropriately, making an ''analogy'' between structural priming and analogy results in a number of novel predictions. In our experiment, we test these predictions and find that our analogical account of structural priming is well supported. Critically, our account uses a single mechanism to predict that structural priming results from formulating the *meaning* of utterances in addition to determining utterances' syntax, while other accounts have focused on the priming and development of syntactic representations (e.g., Shimpi et al., 2007).

Below, we briefly review key principles of analogy and discuss how analogy can give rise to structural priming. We then consider the developmental trajectory of analogy and make novel predictions with regard to the development of structural priming. Finally, in light of our results and theory, the continuity of aspects of language and cognition is considered from both a developmental and computational perspective.

2. Structural priming as analogy

We propose that the mechanism underlying structural priming is the same that underlies analogical reasoning, that is, the mapping of relational structure across domains, or *structure-mapping* (see Falkenhainer, Forbus, & Gentner, 1989; Gentner, 1983; Gentner & Markman, 1997; Hummel & Holyoak, 2003; and Larkey & Love, 2003 for varying computational implementations of relational mapping). Thus, for one utterance to prime another, one must recognize the common relational structure upon which analogy is based.

Utterances' semantics and syntax each contribute to their relational structure. The relevant aspect of semantics is often called the ''thematic structure'' (see e.g., Jackendoff, 1990). Take the example prime utterance from above: ''The father is giving his son some cake.'' This utterance expresses the semantic, or thematic, relation of ''transfer'' as specified by the thematic role set of agent, recipient, and theme; that is, the agent transfers the theme to the recipient. This utterance is in the DO dative construction and shares this thematic relational structure with the PP.[1] ''Transfer'' as encoded in the dative construction, can be physical, or more abstract, as in the transfer of information. The target scene from the example above depicts a girl in a classroom telling a story. Mapping the relational semantics of transfer will lead to an increase of both dative alternates, for example, ''The girl is telling her friends a story'' and ''the girl is telling a story to her friends,'' relative to the use of utterances like ''the girls are having fun,'' which represents no recipient role and thus no transfer relation.

However, the DO and the PP differ in their syntactic relational structure. Here, what we mean by syntactic relational structure are simply word order relations. The two constructions sequence the same set of thematic roles differently (theoretically due to differing hierarchical phrase structures, e.g., Chomsky, 1957). Thus, mapping both syntactic and thematic relations will lead to an increase in using the prime construction relative to the other dative alternate, for example, ''the girl is telling her friend the story'' instead of ''the girl is telling the story to her friend.''

Like analogies, mappings between prime and target utterances occur as a matter of degree. With dative constructions, primes and targets can match on semantic relations, or both syntactic and semantic.[2] Distinguishing between semantic and syntactic structural priming is uniquely made from our structure-mapping account. Because most previous interest in structural priming has been to investigate syntactic representations in adults (e.g., Bock, 1986) and their development in children (e.g., Savage et al., 2003; Shimpi et al., 2007), they have largely ignored the priming of semantic or thematic structure (although see Chang, Bock, & Goldberg, 2003, where priming of thematic role *sequences* was investigated).

Other mechanistic models of structural priming attempt to account for the increased usage of one syntactic alternate relative to another to express the same meaning. They do not attempt to account for the increased use of a set of constructions that can express the same meanings relative to unrelated constructions that express different meanings. This is because they are modeling how one grammatically encodes a predetermined semantics (e.g., Chang et al., 2006; Pickering & Garrod, 2004) or whether a particular syntactic structure has developed, implicitly assuming the semantics have (e.g., Savage et al., 2003; Shimpi et al., 2007). In contrast, we investigate both how the meaning *and* grammar of an utterance are produced. We are examining mechanisms of how messages are formulated, not just how a message is grammatically encoded.

In Chang et al. (2006), structural priming is the result of a competition between alternate sequences of the same thematic role set, and so the priming of one sequence is at the cost of the other.[3] However, semantic-structure-only priming will result in an increase in usage of both syntactic alternates equally. To support our account we need to document semantic-only priming. We generate predictions for this phenomenon from the developmental trajectory of the ability to map relations in young children.

3. The development of structural priming and analogy

There are two major findings regarding the development of analogical mapping that are relevant for our experiment. First, younger children, or children with less relational knowledge, are limited to relationally simple mappings (e.g., Andrews & Halford, 2002; Ratterman & Gentner, 1998a). Andrews and Halford (2002) suggest that relational complexity increases with the number of arguments in a relation, and with the number of relations to consider within a problem or decision. They show that across a variety of tasks (e.g., hypothesis testing and sentence comprehension) children's capacity for relational complexity increases continuously from ages 3 to 8. Interestingly, Ratterman and Gentner (1998a,b) show that capacity for complexity increases not just with age, but with relational knowledge within the specific domain being mapped.

The second important finding is that surface similarities between domains facilitate the mapping process, allowing the appreciation of more complex mappings (e.g., Gentner & Rattermann, 1991; Loewenstein & Gentner, 2001). For example, Loewenstein and Gentner (2001) showed that shared surface features enabled young children to recognize the structural commonalities in the spatial arrangement of items across two model rooms (see similar findings in Ratterman & Gentner, 1998a).

The first finding relates to our account of structural priming because we have discussed two forms of structural priming, differing in their degree of relational complexity. Semantic-relations-only priming is simpler than full priming because the latter entails mapping both semantic and syntactic relations. The thematic relation of transfer is a predicate with three arguments, called a *ternary* relation. Correspondingly, the relevant word order relation is also ternary, one argument slot for each of the three places in the sequence. Thus, semantic-relations priming entails mapping only a single ternary relation, while full structural priming entails integrating and mapping two ternary relations. In addition to the added complexity, full structural priming requires more knowledge of syntactic relations than semantics-only priming. Therefore, according to both relational complexity accounts (Andrews & Halford, 2002) and relational knowledge accounts (Ratterman & Gentner, 1998a), younger children are more likely to demonstrate only semantic structural priming while older children will show full priming.

The second finding suggests that shared surface similarity between prime and target utterances will aid in structural priming. Shared surface similarity in the meanings of utterances is analogous to the shared perceptual features across items in Loewenstein and Gentner's (2001) spatial mapping task. Thus, increasing the shared surface similarity should increase the likelihood that younger children will make both semantic and syntactic mappings.

Thus, our structure-mapping account makes the novel testable predictions that the surface similarity between utterances will facilitate younger children's identification of common structures, and that children's representations of thematic roles can be primed independently of syntactic relations.

4. The experiment

The current study manipulates the semantic similarity between prime and target utterances to demonstrate its facilitatory effect on young children's priming. Surface similarity was defined by membership to scene category; there were sports scenes, food scenes, and classroom scenes. Within the category, similarity is increased by semantically related verbs, for example, in the classroom scenes, *telling* and *teaching*, as well as semantically related nouns, *classmates* and *students* (see Fig. 1).[4]

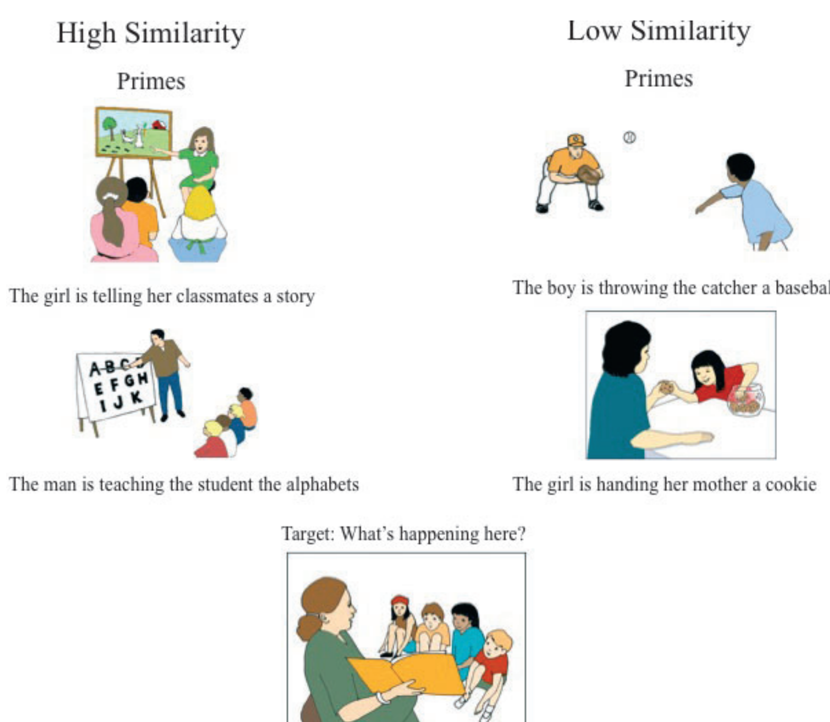

Fig. 1. An example block from high- and low-similarity conditions.

The task consisted of three critical blocks of three scene descriptions each. In the high-similarity condition, each block consisted of all three scenes from the same category, whereas the low-similarity condition used one scene per category in each block. The first two scenes of each block were described by the experimenter, and the child then described the third scene on his/her own (see Fig. 1 for an example trial in each similarity condition). The primes described the scenes with either the PP or the DO. Prime construction and similarity conditions were manipulated between participants. In addition, we ran a ''prime-free'' baseline in which the children described all the scenes without any experimenter descriptions.

Semantic structural priming is measured by comparing the total number of both dative alternates combined, as compared to the total in the prime-free baseline. Full structural priming, that is, semantic and syntactic, is measured by comparing the number of target utterances that matched the particular dative alternate used in the prime against the number that used the mismatching dative alternate. It is critical to compare matching dative utterances to mismatching utterances. If the analysis just contrasted number of matches across conditions, an increase in matches could appear to be a sign of full structural priming, but if there was a corresponding increase in mismatching datives, then this would actually be a sign of increased semantic structural priming.

We predict that 4-year-olds will only show full structural priming when aided by surface semantic similarity between prime and target utterances, but may show semantic priming without this aid. Five-year-olds should be able to show full structural priming without shared surface similarity.

To summarize our account: We propose children store both semantic and syntactic contributions to the relational structure of utterances, and then retrieve these structures from memory, contributing to the formation of further utterances. Because mapping relationally complex structures is difficult for younger children, they will be more likely than older children to require aids such as shared surface similarity for success at retrieving and mapping both semantic and syntactic relations.

5. Method

5.1. Participants

Fifty-eight 4-year-olds, 29 males and 29 females, ranging from 4.1 to 4.5 (average 4.3), participated. Sixty-seven 5-year-olds, 35 males and 32 females, ranging from 5.1 to 5.5 (average 5.3) participated. Ten of the 125 total children were removed from analysis for fussiness, inattention, or experimental error. All were recruited from the Austin area. Children were compensated with a t-shirt for participation. Four- and five-year-olds were selected because crucial developmental changes are measured across these age groups in both analogy and language tasks (e.g., Ratterman & Gentner, 1998b; Savage et al., 2003). Specifically, Ratterman and Gentner (1998b) show development from the age of 4 to 5 years in recognizing relation-based similarity across items.

5.2. Materials

There were nine critical scenes and six warm-up scenes. They were broken up into sets of three, making three critical blocks and two warm-up blocks. The warm-up blocks served to familiarize the children with the turn-taking procedure. The scenes in the first warm-up block were described with intransitives, the second with transitives. The nine critical scenes contained three food scenes, three sports scenes, and three classroom scenes. The critical scenes were described with dative constructions. In all blocks, the first two scenes were primes and the third was a target. Parents completed a vocabulary and grammar checklist to ensure that the children knew the words and constructions used in the experiment.

5.3. Procedure

Children were tested individually and were told they would play a game with pictures. The scenes in the critical blocks were described with the DO or PP dative. The first two were described by the experimenter and the child repeated. If the child did not adequately repeat the sentence, he/she was immediately encouraged to try again with some help from the experimenter. Repetition has been shown to not affect priming in these age groups (e.g., Huttenlocher, Vasilyeva, & Shimpi, 2004; Savage et al., 2003), so it was used to ensure that children were engaged in the task. The third scene was described by the child on his/her own; this provided the primary data used to assess priming.

After the warm-up blocks, the rest of the experiment was run in one of two similarity conditions (see Fig. 1). In the high-similarity condition, each block consisted of three scenes from the same category, whereas the low-similarity blocks consisted of one scene per category. Across conditions, scenes maintained their within-block order; for example, if a scene was the first of two primes within a block in one condition, then it was the first within the block in the other similarity condition. This insured that the same scenes were used as test scenes across high- and low-similarity conditions.

Within a single block, specific noun and verb phrases differed across prime utterances. In both similarity conditions, some noun phrases were reused across blocks, but no verb phrases were. Clearly, closed-class words were repeated. If a child did not know a word used in the prime descriptions according to parental report, it was replaced with a word the child did know, while still maintaining the rule that no noun phrases were repeated within a block. Parents reported that all verbs were known.

In addition, a separate group of children participated in a baseline condition in which they described all scenes on their own without help from the experimenter; however, for consistency with the other conditions, only target scene descriptions were analyzed. The same block and scene orders were used as for the prime conditions.

5.4. Design summary

For both age groups, two variables were manipulated between subjects. The first was the similarity of the scenes within the three blocks of trials. The second was how the

Table 1
Number of children participating in each condition

Prime Construction	Prepositional Phrase	Direct Object
4-year-olds		
High similarity	9	10
Low similarity	9	10
5-year-olds		
High similarity	11	12
Low similarity	12	13
	Baseline	
4-year-olds	13	
5-year-olds	16	

experimenter described the prime scenes. The experimenter either described the primes with the DO constructions, the PP construction, or not at all in the baseline in which the children described all the scenes (see Table 1 for subject number totals for each condition).

Both variables were manipulated between subjects to avoid any interference from switching conditions across blocks of trials (see Conwell & Demuth, 2007). In addition, manipulating prime construction between subjects is consistent with previous work (e.g., Shimpi et al., 2007). Finally, random assignment and the grammar and vocabulary checklist ensured any differences in language knowledge between prime construction groups were minimal.

6. Results

6.1. Scoring procedure

Three experimenters coded trials. Half of the trials were coded by more than one experimenter, and there was no disagreement. To ensure that the children were attending to the prime constructions, prime trials were coded for successful repetitions of the experimenters' descriptions. All children repeated at least one prime successfully for all blocks of trials. For the target utterances, verb and construction produced were recorded.

For a construction to be counted as a prepositional dative, it needed a verb, and three noun phrases in the order agent, theme, then recipient. For a construction to be counted as a double object dative, it needed a verb, and three noun phrases in the order agent, recipient, then theme. Transitives, intransitives, and sentence fragments were coded as ‘‘other.’’

6.2. Data analysis

First, we test for semantic structural priming, and then we test full semantic and syntactic priming. We test for semantic structural priming by comparing the total number of datives produced by each child from each similarity condition with their age groups' baseline. As there were three test trials, the maximum number of datives per child is 3.

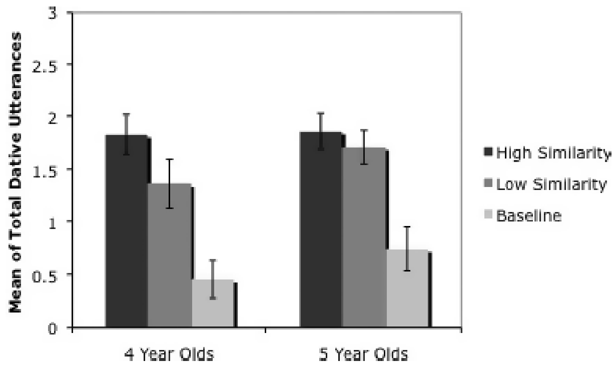

Fig. 2. Semantic structural priming: Total datives produced for target utterances per child, out of three trials. Means and standard errors shown.

Here, all conditions and age groups show reliable priming (see Fig. 2). For the 4-year-olds, we conducted a one-way three-sample ANOVA, revealing reliable differences, $f(2, 48) = 9.31$, $p < .001$. Both high-similarity ($M = 1.84$) and low-similarity ($M = 1.37$) 4-year-olds produced more datives than the 4-year-old baseline ($M = 0.46$); Tukey HSD [0.05] = 0.75, with $d = 1.7$ comparing high similarity to baseline, and, $d = 1.02$ comparing low to baseline. The high- and low-similarity groups did not differ from each other. The same pattern held for the 5-year-olds as revealed by the one-way three sample ANOVA, $f(2, 61) = 9.5$, $p < .0001$, with high similarity ($M = 1.87$), low ($M = 1.72$), baseline ($M = 0.75$); Tukey HSD [0.05] = 0.63, $d = 1.35$ comparing high and baseline, and $d = 1.14$ comparing low and baseline.

To test for full structural priming, we compared the number of dative matches (a DO target when there was a DO prime or a PP target with a PP prime) with dative mismatches (a DO target with a PP prime and vice versa). Full structural priming is shown by children producing significantly more matches than mismatches.[5] Our predictions were that 4-year-olds would need shared content between prime and target utterances to show priming, but the 5-year-olds would not. The predictions were confirmed (see Fig. 3). For the 4-year-olds, we conducted a 2 (Similarity: High vs. Low) × 2 (Construction Match: Match vs. Mismatch) mixed measures ANOVA. There were no reliable main effects of either similarity or matching, p's > .1, but crucially, there was a reliable interaction, $f(1, 36) = 5$, $p < .05$. The factors interacted because the high-similarity 4-year-olds matched the prime dative ($M = 1.32$) more than they mismatched ($M = 0.52$), $t(18) = 2.22$, $p < .05$, $d = 0.51$, whereas the low-similarity condition showed no such effect (Match $M = 0.58$; Mismatch $M = 0.79$), $t(18) = -0.78$, $p > .4$, $d = -0.18$. We also conducted a 2 (Similarity) × 2 (Construction Match) mixed measures ANOVA, for the 5-year-olds. Here, there was neither a main effect of similarity nor a similarity by construction matching interaction p's > .4, but a main effect of construction matching, $f(1, 46) = 29.39$, $p < .0001$. This pattern is obtained because both similarity groups showed the priming effect. The high- and low-similarity children matched (High $M = 1.48$; Low $M = 1.28$) more frequently than mismatched (High $M = 0.39$; Low $M = 0.44$), $t(22) = 4.08$, $p < .01$, $d = 0.85$ and $t(24) = 3.56$, $p < .01$, $d = 0.71$, respectively.

To further show the need of shared surface similarity for 4-year-olds to map both semantic and syntactic relations even in the high-similarity condition, we analyze the dependence of structural priming on repeating a verb from a prime utterance (within the same block). The analogous analyses could not be done for the low-similarity condition, because verb repetition did not occur, given the dissimilarity between scenes within a block. Because children differed in the number of trials they repeated verbs, proportions are analyzed instead of sums. The proportions are calculated as the number of matches or mismatches divided by the number of total utterances (i.e., matches, mismatches, and nondatives) when a verb was repeated.

The younger children only showed full structural priming when they repeated verbs (see Fig. 4). When repeating verbs, the 4-year-olds matched (M = 0.92) more frequently than

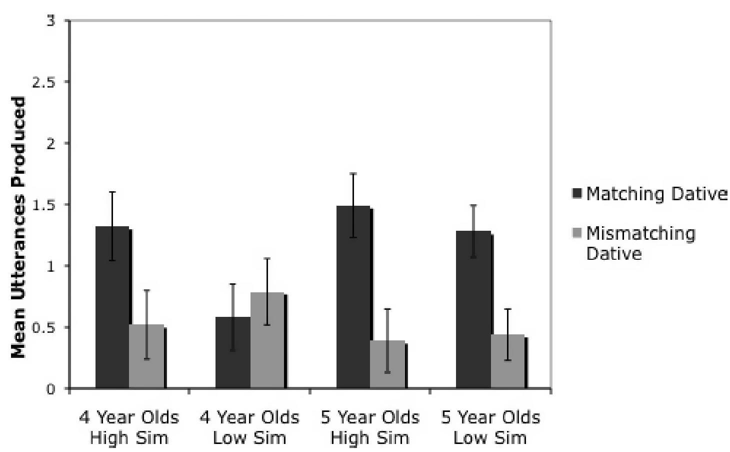

Fig. 3. Full structural priming: Contrasting target utterances that matched the prime dative alternate with mismatching datives, out of three trials. Means and standard errors are shown.

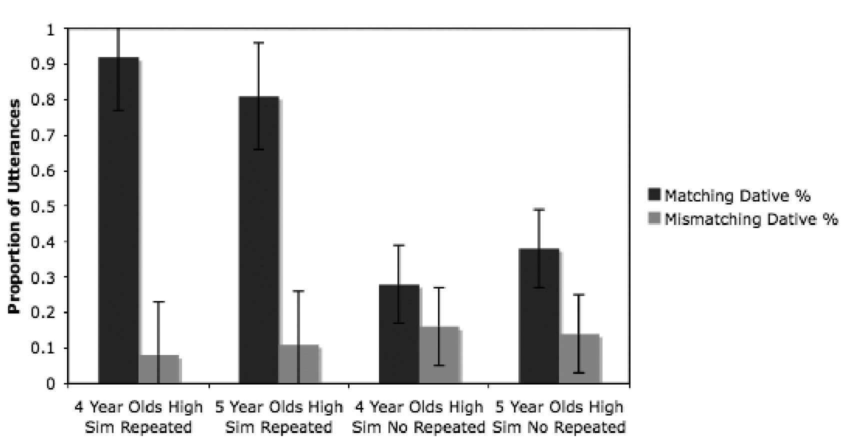

Fig. 4. Verb repetition and full structural priming: Contrasting the proportion of target utterances that matched the prime dative alternate with mismatching datives. Means and standard errors are shown.

mismatched ($M = 0.08$), $t(12) = 5.5$, $p < .01$, $d = 1.53$. When they did not repeat verbs, they did not match ($M = 0.28$) significantly more than they mismatched ($M = 0.16$); $t(18) = 0.95$, $p > .3$, $d = 0.22$. In contrast, 5-year-olds in the high-similarity condition showed priming regardless of verb repetition, matching more frequently ($M = 0.81$) than mismatching ($M = 0.11$), $t(17) = 4.57$, $p < .01$, $d = 1.08$, when repeating verbs and matching ($M = 0.38$) more frequently than mismatching ($M = 0.14$) when not repeating verbs, $t(22) = 2.08$, $p < .05$, $d = 0.43$. When the 4-year-olds in the high-similarity condition did not repeat verbs, they still showed semantic priming, that is, a higher proportion of total dative responses ($M = 0.44$), when compared to baseline ($M = 0.15$), $t(30) = 2.38$, $p < .05$, $d = 0.86$.

7. Discussion

In keeping with our predictions, 4-year-olds only showed full structural priming when there was high surface similarity between prime and target scenes and utterances, that is, when the scenes came from the same event category. The simpler mapping of semantic relations-only priming required neither verb repetition nor high similarity. The 4-year-olds in the low-similarity condition, and high-similarity condition when not repeating verbs, showed this semantic role set priming. This means that a prime in one dative alternate increased the likelihood of the use of both dative alternates equally in a subsequent scene description. This is predicted by our account, but it is unaccounted for by other models or theories (e.g., Chang et al., 2006; Pickering & Branigan, 1998; Savage et al., 2003; Shimpi et al., 2007). In addition, the finding that the 5-year-olds showed full structural priming in all conditions and not dependent on repeating verbs suggests the ability to retrieve and map more sophisticated relational linguistic structures develops between ages 4 and 5.

In sum, we proposed that children store the form of utterances, and then retrieve and map their relational structure to guide formation of further utterances. Because 4-year-olds are worse at this than 5-year-olds, they require more shared surface similarity across domains to enable complex relational mapping or mappings where relational knowledge is limited (Andrews & Halford, 2002; Gentner & Rattermann, 1991; Ratterman & Gentner, 1998a,b).

8. Implications for grammatical development

Previous studies in children's structural priming have been used to argue whether children have abstract syntactic representations, that is, whether constructions have been generalized across lexical items. The reasoning is that, if structural priming is shown without verb repetition, then the representation of constructions is considered verb-general. There are two issues to discuss here.

The first issue is that our findings appear inconsistent with some others in this literature, creating important questions for future research. Thothathiri and Snedeker (2008) show between-verb priming in a 4-year-old's comprehension of datives, while we only show it within-verb for 4-year-olds' production. However, comprehension often appears ahead of production. In fact, Chang et al.'s (2006) model simulations show an earlier maturity for comprehension tasks than production using a single learning mechanism. Still, the relation between how priming guides language comprehension and production remains an important issue to investigate further.

In addition, Shimpi et al. (2007) show dative priming in 4-year-olds' production even though verbs used in the target utterances differed from the verbs in the primes. However, there are many methodological differences between our study and theirs. For one, their children received 10 primes before producing 10 targets, creating more of a chance for priming to build across trials than in ours. In addition, it is less clear how to analyze for verb repetition and scene similarity contingencies given how their scenes were blocked. A complete theory would have to account for both sets of results given these methodological differences. This warrants further investigation.

The second issue to address is that regardless of these apparent inconsistencies, it is unclear whether structural priming reflects the state of a child's grammatical knowledge; that is, it is not necessarily the result of ''tapping into'' their preexisting syntactic representations, abstract or lexeme specific. Our results can be explained by children's use of the surface form of the utterances in the experiment to guide further sentence production. This can be accounted for by a relational reasoning exemplar model (Tomlinson & Love, 2006) that needs no permanent grammatical knowledge, but simply represents the semantic role and word order relations of the exemplar utterances. We are not denying that children have grammatical knowledge beyond this, but that grammatical knowledge may be unnecessary to account for the repetition of structure in turn-taking scene description tasks. However, our results are suggestive of the 4-year-olds having less syntactic knowledge than the 5-year-olds because it is possible that the inability to map syntactic relations is not due to processing capacity limits, but because of a dearth of relational knowledge (see Ratterman & Gentner, 1998a,b).

In addition, it is possible that behavior in these tasks is reflective of grammatical knowledge, but that knowledge changes throughout the course of the experiment. Analogical processes are also learning mechanisms (e.g., Kotovsky & Gentner, 1996). Gentner and Medina (1998) argue that analogical comparison is critical in rule learning. In Shimpi et al. (2007), the children hear and repeat 10 primes and then describe 10 target scenes. It is rare that 10 straight utterances are of the same construction; it is just this sort of sequence that would allow an analogical learning mechanism to abstract the grammatical rule (e.g., Tomlinson & Love, 2006).

Structural priming as learning is consistent with Chang et al. (2006). However, that model uses a different learning mechanism and only focuses on syntactic priming (as defined here). Evidence for Chang and colleagues' implicit learning account comes from long-term effects of priming, and they suggest that short-term priming effects may be achieved by a different mechanism. Pickering and Garrod (2004) propose that these short-term effects are the result of conversants aligning their grammatical representations and are in the service of making dialogue more fluent. It is quite possible that children achieve this alignment through relational mapping. Our results are the first to show that analogical mapping mechanisms are involved in dialogue; however, more research is needed to confirm that these mechanisms are helping to achieve fluency or aid in grammatical acquisition.

How analogical mapping and learning mechanisms relate to developing grammatical knowledge is a crucial area of future research. Analogical processing is implicated in many domains of cognition and to our model attempts to both make language tasks continuous with other aspects of cognition and to drive predictions. This perspective's first novel prediction, confirmed in this paper, was that semantic representations (independent of sequence) are primed in structural priming tasks. In past developmental research, syntax alone was the focus. We will continue to investigate how much of language phenomena can be explained or predicted from this perspective, building on this important first step.

Notes

1. See Goldberg (1995) for discussion of fine grain semantic differences between dative alternates.
2. These constructions have semantics constrained to describing transfer events, making syntactic-only priming impossible.
3. Typically in the model priming is a result of thematic role sequence competition, but the model can also account for priming of syntactic structure that has been de-correlated from thematic role sequence (Bock & Loebell, 1990). However, this is again about priming one specific syntactic alternate at the cost of the other.
4. To confirm that both the nouns and verbs were more similar to each other in the high-similarity condition than in the low-similarity condition, we obtained their Latent Semantic Analysis similarity scores (Landauer & Dumais, 1997). We compared the postverbal nouns of one prime utterance to the postverbal nouns used in the other prime utterance from the same block of trials for each similarity condition (the same few nouns were used for subjects across all primes). The average similarity (on a scale of −1 to 1) for the high-similarity nouns was 0.41, while the average for the low-similarity nouns was 0.06. The analogous analysis for the verbs showed the high-similarity verbs had an average score of 0.43, while the low-similarity verbs had an average score of 0.23.
5. Another way to analyze the data is to perform a 2 (prime construction) × 2 (target construction) ANOVA, and priming is shown by a significant interaction. These analyses show the same pattern of effects as the analyses presented.

Acknowledgments

Support for this research was provided by NSF grant 0447018 to the third author. We thank Kelli Gross and April Hernandez for their able research assistance and Franklin Chang, Adele Goldberg, Art Markman, and three anonymous reviewers for valuable discussion of the work. We are grateful to the children who participated, their families, and Julie Wall of the Children's Research Laboratory for their indispensable roles in this research.

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