

Structural Priming and Non-surface Representations

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Structural priming is a tendency for speakers to produce sentences that are structurally similar to their previous utterances. While there are many types of syntactic structures that linguists may be inclined to consider structurally similar, a goal of this paper is to ask what type of similarity is tapped by structural priming—that is, what kinds of structural representations must be accessed for purposes of sentence production. Previous psycholinguistic studies have focused on phrase- and sentence-level alternations such as dative shift and the transitive alternation (passive), with the understanding that structural priming can tell us something about the structural representations that are ultimately realized as alternate surface forms.

This study shows priming between unaccusatives and passives—two sentence types that superficially look very different, but nevertheless are often considered to have similar syntactic properties. If structural priming targets similar syntactic structures, these results suggest that unaccusatives and passives are structurally alike at some level of representation that is accessed during sentence production, and further, that the similarity is one that does not survive in surface form. In the big picture, together with a theory of the priming mechanism (not provided here), the presence or absence of structural priming effects can tell us something about how these structures are generated—for instance, what their atomic parts are, how these elements are represented in the lexicon, and how they are related to the items that get mapped onto syntactic representations.

This paper is organized as follows. The first section reviews the relevant psycholinguistic literature on structural priming, and lays out the minimal assumptions I make about the syntax of passives and unaccusatives. Section 2 presents a picture description experiment showing structural priming between unaccusatives and passives; section 3 presents a similar experiment that incorporates psych verbs in order to eliminate a confound present in the Experiment 1. Section 4 concludes the paper.

1. Background

1.1 Structural priming

When a speaker has produced an utterance having a particular syntactic structure, a subsequent utterance by that speaker tends to match the structure of the previously produced sentence; this behavioral effect is known as structural priming. An early demonstration of this in a controlled experimental setting was by Bock (1986b), and involved dative shift: a ditransitive sentence produced in double object form was more likely to be followed by another double object sentence than a prepositional dative sentence

was, as in (1). Likewise, as in (2), a prepositional dative sentence was more likely to be followed by another prepositional dative sentence than a double object sentence was.

- (1) a. The boy gave the girl a present (prime)
b. The student showed the teacher a drawing (target)
- (2) a. The boy gave a present to the girl (prime)
b. The student showed a drawing to the teacher (target)

Structural priming has been shown to occur with various syntactic alternations, typically using variants of either a picture description paradigm (Bock 1986b, ff.) or Potter and Lombardi's (1990) immediate recall paradigm with rapid serial visual presentation (RSVP). In addition to dative shift (Bock 1986b, 1989; Bock and Loebell 1990; Bock and Griffin 2000; others), priming has been demonstrated for active-passive pairs (Bock and Loebell 1990; Bock and Griffin 2000), locative inversion (Hartsuiker, Kolk and Huiskamp 1999, in Dutch), preposition stranding in question-answer pairs (Levelt and Kelter 1982, in Dutch), and particle placement in verb-particle constructions (Konopka and Bock 2005).

Since pairs of sentences can be similar to each other in many ways, much of the existing literature tries to show that there is an independent effect of structure that can be isolated from various non-structural factors. For instance, Bock (1986b) showed that structural priming cannot be reduced to lexical priming from content words (e.g. the verb), by showing that priming occurs in the absence of lexical overlap from prime to target (also Potter and Lombardi 1990; and others).

A number of other possible alternative explanations for structural priming are checked and excluded in Bock and Loebell (1990), including priming from prosodic structure, and priming of thematic structure. While these other factors might very well influence aspects of subsequent utterances, the claim is that these alone cannot account for structural priming. For example, sentences like (3a), where 'the church' is a location/destination, were shown to prime sentences like (3c), where 'the boy' is a goal, as much as (3b) does, where 'the church' is a goal.

- (3) a. The wealthy widow drove her Mercedes to the church (prime)
b. The wealthy widow gave her Mercedes to the church (prime)
c. The girl gave the present to the boy (target)

Since the magnitude of priming is not reduced by non-overlap of thematic roles, the source of priming in this case is argued to be the shared 'NP PP' structure. Control sentences with matching string word order, prosodic structure, and lexical content, but different syntactic structure did not show priming: (4a) does not prime (4c), while (4b) does.

- (4) a. Susan brought a book to study (prime)
b. The boy gave a present to the teacher (prime)
c. Susan brought a book to Stella (target)

A similar case is *to*-datives (*The secretary is taking a cake to her boss*) and benefactives (*The secretary is baking a cake for her boss*), which differ in the thematic role assigned to the PP argument; in the examples given, 'to her boss' is a Goal/Location, whereas 'for her boss' is a Beneficiary. Bock (1989) observed that this mismatch in thematic structure does not affect structural priming, much like Bock's (1986b) finding that there is no additional priming benefit due to matching thematic structure.

Structural Priming and Non-surface Representations

With regards to what structural priming actually targets, different researchers propose slightly different things, depending on their theory of the priming mechanism. For Pickering and Branigan (1998), verb representations are linked to combinatorial nodes (roughly: subcategorization frames; for the dative shift case, [NP_PP] competes with [NP_NP]), and priming is when activation on a combinatorial node is bumped up from recent selection. Chang, et al (2000), Bock and Griffin (2000), and Bock et al (1996) argue that structural priming is a form of implicit learning; structural options are possible surface orderings of arguments, given the event semantics and a set of thematic roles, whose baseline level of activation can increase as a result of experience and usage. But one thing these and other accounts have in common is the assumption—implicit or explicit—that only syntactic frames with the same number of arguments are 'eligible' for priming, as stated explicitly by Griffin and Weinstein-Tull (2003). Given a verb and a set of arguments it selects, priming is something that affects which of the possible output configurations is more or less likely to be produced. On this view, priming is truly about alternations, and not about any more general notion of structural similarity. From the point of view of syntactic theory, however, verbs might be grouped together—thought of as sharing structural properties—if there is something similar about how their underlying representations map to surface configurations. The experimental results in this paper point to this latter view of structural similarity.

1.2 Passive

Active-passive pairs—the so-called transitive alternation—have been one of the exemplifying cases of structural priming, as described above. It's clear that such sentence pairs are related to each other in some systematic way: take a simple example like (5).

- (5) a. Abby kicked Sue
b. Sue was kicked by Abby

The descriptive generalization is that (5b) encodes the same thematic relations as (5a), and as such has the same truth conditions—Abby is the kicker and Sue is the 'kickee'. Such pairs seem like they should have a common representation at some level for reasons of parsimony; since the relationship between the forms is systematic, some kind of rule or transformation should be able to take you from one form to the other.

Three characteristic features of passives distinguish them from actives. First, the external argument of the active sentence no longer appears in the subject position—instead it appears optionally in a by-phrase. Second, an internal argument of the active verb is promoted to subject position. Third is the form of the verb—the passive auxiliary 'be' is present in the passive form, and the main verb has participial morphology.

With respect to the verbal morphology, passives differ from unaccusatives. In fact, unaccusatives are incompatible with passive (**The messenger was arrived*); in a transformational theory, this is presumably because you can't passivize a verb that lacks an external argument. On the other hand, passives share with unaccusatives the property of having derived subjects—as discussed in the next section, if some version of the Unaccusative Hypothesis is right, surface subjects of unaccusative verbs are underlying internal arguments.

1.3 Unaccusatives and the Unaccusative Hypothesis

Unaccusatives have been argued to share syntactic properties with passives; but unlike passives, it's not the case that unaccusative sentences are thought to be derived from a basic alternant that also exists as a surface form—that is, they don't form part of an alternating

pair analogous to passives and actives, or middles and actives¹. In that sense, any structural parallels that can be drawn between unaccusatives and passives must be non-item-specific; in fact, any such similarity will not even be tied to predicate-argument structure, since verbs appearing in the passive will always be transitive (or ditransitive), while unaccusative verbs will always be intransitive.

Unaccusativity is at the center of the question of how lexical semantics relates to syntactic structure—to be more precise, how linking information is represented in the lexicon². These questions first arose in the context of Perlmutter's (1978) Unaccusative Hypothesis—the generalization was that the class of intransitive verbs further divided into two verb types which appeared in characteristic syntactic configurations. Some examples of intransitive sentences are in (6).

- (6) a. The kids slept/jumped (up and down)/ran
 b. The kids vanished/appeared/stayed (in the pool)

The (a) sentences are said to have unergative verbs, while the (b) sentences have unaccusative verbs. While members of these two verb classes seem to share distinct semantic properties, the difference is defined syntactically. According to Perlmutter, unergatives are verbs that have a single external argument underlyingly (as in (6a)), while unaccusatives have a single internal underlying argument (as in (6b)). (7) represents these configurations while also taking into account the VP-internal subject hypothesis (Koopman and Sportiche 1991)³.

- (7) a. [VP NP [v' V]]
 b. [VP [v' V NP]]

If the syntactic property that defines unaccusativity is the lack of an external argument, unaccusatives look a lot like passives underlyingly.

There seem to be empirical reasons to think that the unique argument of an unaccusative verb is base-generated post-verbally, in the canonical object position, and is promoted to subject position (or some other pre-verbal position, in *there*-insertion contexts). Diagnostics for surface unaccusativity—like availability of *there*-insertion and locative inversion, or compatibility with resultatives—rely on this structural property to distinguish unaccusatives from unergatives, so as far as those diagnostics give us a way to sub-classify intransitive verbs that seems meaningful, some version of the original Unaccusative Hypothesis must hold. This parallels an account of passivization where the surface subject argument of a passive is base-generated in object position (in its designated theta position), and is promoted to subject position, and this shared syntactic property is what Experiments 1 and 2 test for.

2. Experiment 1: Priming from Unaccusatives to Passives

¹This isn't entirely true, since a subset of the class of unaccusative verbs participate in the Causative-Inchoative alternation, as discussed later in this section.

² See e.g. Grimshaw (1979, 1981), who argues for an autonomous subcategorization, since semantic selection (s-selection) alone cannot predict categorial selection (c-selection) properties of verbs; Pesetsky (1982) argues further that the subcategorization properties discussed by Grimshaw are linked to (Accusative) Case-assigning properties of particular lexical items.

³ Or perhaps:

- (i) [VP NP [v' V [VP [v' V]]]]
 (ii) [VP NP [v' V]]

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Experiment 1 uses a picture description paradigm adapted from Bock (1986b, ff.) to see whether unaccusative primes would behave like passive primes in increasing the number of passive sentences produced on subsequent picture description trials.

2.1 Methods

Participants. Subjects for the experiment were undergraduate students from UCLA. 47 native speakers of American English participated in the experiment. They received either credit toward fulfilling a requirement in an introductory linguistics course, or \$8, for their participation.

Materials. A priming sequence is one sequence of trials consisting of (i) four filler items, (ii) one prime sentence, and (iii) one target picture, as represented in Table 4.

Trial	Event	Response
1	Filler number set ('23 43 15')	Repeat; Old/New decision (button press)
2	Filler number set ('31 98 55')	Repeat; Old/New decision (button press)
3	Filler word set ('opponent courage fiction')	Repeat; Old/New decision (button press)
4	Filler word set ('mystery canvas liquid')	Repeat; Old/New decision (button press)
5	Prime sentence ({'The detective was interrogating the inmate'/'The inmate was being interrogated by the detective'/'The representative was arriving late'})	Repeat; Old/New decision (button press)
6	Target picture (picture of a horse kicking a man)	Describe; Old/New decision (button press)

Table 1. Sample priming sequence for Experiment 1.

There were 36 black and white pictures, each one depicting a transitive event that could be described by either an active or a passive sentence. All of the experimental pictures depicted participants matching in animacy—they either had two inanimate entities (e.g. *The tank is crushing the bicycle*) or two animate entities (e.g. *The tiger is chasing the man*, or *The dog is pulling the boy*). To control for potential left-right orientation effects, two mirror image versions were created for each target picture; lists were counterbalanced such that one version of each picture was seen by each subject, and each version of each picture was seen an equal number of times across subjects.

Description norms were collected for the target pictures. 14 students (different from those who participated in the experiment) were asked to describe the events depicted as the images were displayed in random order on a computer screen. Participants in the norming study typed their responses on the keyboard, and pressed a key to proceed to the next picture. 75.6% of all responses were sentences with transitive main verbs (active or passive). Two pictures were subsequently removed because they elicited uncodable responses (non-active/passive forms) on all but one or two responses; 79.8% of remaining responses (pooling all participants' responses) were active sentences, and 20.2% were passives. Within this subset of descriptions, the mean percentage of actives across participants was 80.2% (range 62.5-93.6%), and the mean percentage of passives was 19.8% (range 6.4-37.5%).

The 36 prime sentences were divided into equal numbers of three prime types for each run of the experiment. 24 primes were sentences with transitive verbs, each of which

had active (e.g. *The detective was interrogating the inmates*) and full passive (e.g. *The inmates were being interrogated by the detective*) counterparts. The remaining 12 primes were intransitive sentences with unaccusative verbs (e.g. *The contestants were arriving on time*). Sentences were digitally recorded at a sampling rate of 44kHz by a male native speaker of North American English. In half of the filler items, a set of three frequency-matched words appeared on the computer screen; the task was to repeat the words into the microphone, then decide whether that set of words (in the given order) had appeared earlier in the experiment. Similarly, in the other half of the fillers, a set of three numbers appeared on the screen, and the task was to say the numbers into the microphone, then make an old/new decision. There were a total of 218 items in the experiment (36 primes, 36 targets, and 146 fillers between priming sequences, divided into 36 blocks of 4 fillers each), plus 8 practice items.

Design. The experimental conditions varied by Prime type, and are shown in Table 2. Each subject saw 12 prime sequences from each of the 3 cells of the experiment. The dependent measure was Response type (Passive responses as a proportion of the total number of codable responses per cell).

Prime type		
<i>Active</i>	<i>Passive</i>	<i>Unaccusative</i>
<i>'The detective was interrogating the inmate'</i>	<i>'The inmate was being interrogated by the detective'</i>	<i>'The representative was arriving late'</i>

Table 2. Experiment 1: Prime Type.

Four lists were created, all containing 12 active primes, 12 passive primes, and 12 unaccusative primes in random order; each of the four lists was paired with a different randomly ordered list of target pictures, to generate four fixed lists with different prime-target pairings. Active and passive versions of the transitive primes were counterbalanced such that a given sentence appeared in active form on two lists, and in passive form on the other two lists. Further, (a different) two lists used target pictures appearing in a particular left-right orientation; the other two lists used mirror image pictures. A set of four filler trials separated each prime-target pair; these were drawn from the same list of fillers in random order.

Procedure. On all prime sentences, subjects listened to the sentence, repeated it into a microphone, then pressed a button to indicate whether the sentence or word list had occurred previously in the experiment or not. For the target pictures, subjects viewed the image and described the event depicted into the microphone, then indicated by button press whether or not they had seen the picture previously in the experiment. For the fillers, a set of either three words or three numbers appeared on the screen, and subjects pressed a button to indicate whether that sequence had appeared previously or not. All events in the experiment were controlled by a Macintosh computer running PsyScope software (Cohen, et al 1993). Sound files were played through headphones worn by subjects during the experiment. Subjects' responses were recorded on a digital recorder for later coding. Following Bock (1986b), subjects were instructed to repeat the sentence, word list or number list they heard or saw on the screen (on prime and filler trials), and describe what was going on in the picture (picture description trials), to help with the memory task.

2.2 Results

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Coding responses. Both *be*-passives (*The swimmer is being attacked by the shark*) and *get*-passives (*The swimmer is getting attacked by the shark*) were counted as passive responses, as were passive sentences without a *by*-phrase (*The swimmer is being attacked*). 18 subjects were excluded from the analysis because they produced fewer than 5% passive responses, leaving 29 subjects.

All responses coded as active or passive had a Theme (or Patient) argument, and an Agent argument (optionally omitted, i.e. implicit, for passive responses), which excluded responses with Experiencer-Theme verbs. Three participants who did not produce any passive responses across conditions were excluded from the analysis, leaving 44 participants. Of the 1584 responses, 90.1% were codable by these criteria, with 180 passive and 1247 active responses. Remaining responses were coded as 'other' and excluded—including responses from trials where the prime sentence was not reproduced successfully, and disfluent utterances with no main verb; 9.9% of all responses were omitted from the analysis.

Analysis. All subjects and items were given a score for each cell of the experiment. A subject's score was the number of target (passive) sentences as a proportion of that subject's codable responses for a particular condition. Similarly, an item's score corresponded to the number of target sentences as a proportion of all codable responses for the item in that condition. Mean percentages of Passive responses by condition and pairwise comparisons of condition means are given in Table 3.

Prime type	<i>Active</i>	<i>Passive</i>	<i>Unaccusative</i>
Mean % Passive responses	8.5	15.3	14
Pairwise comparisons	<i>Passive—Active</i>	<i>Unaccusative—Active</i>	<i>Passive—Unaccusative</i>
Difference in means, Tukey HSD (95% conf. interval)	6.83 (1.68,11.98)	5.53 (0.38,10.69)	1.30 (-3.86,6.45)

Table 3. Summary of Experiment 1 results.

Analysis of variance was performed separately treating subjects and items as random effects⁴. One-way ANOVA showed that condition means were significantly different from each other; this was significant by subjects only ($F(2,26) = 5.64, p < 0.01; F(2,1)$).

As shown in Figure 1, the proportions of Passives produced after both Passive primes and Unaccusative primes were larger than the proportion of Passives after Active primes. Post-hoc pairwise comparisons using Tukey's HSD revealed that these pairs of conditions were significantly different from each other: Active Primes were different from Passive Primes (difference in means = 6.8; 95% family-wise confidence interval (1.68,11.98)), and Active Primes were different from Unaccusative Primes (difference in means = 5.53; 95% family-wise confidence interval (0.38,10.68)).

⁴All analyses reported were also performed on arcsine-transformed data; these analyses yielded the same results as the non-transformed data, so only the latter are reported here.

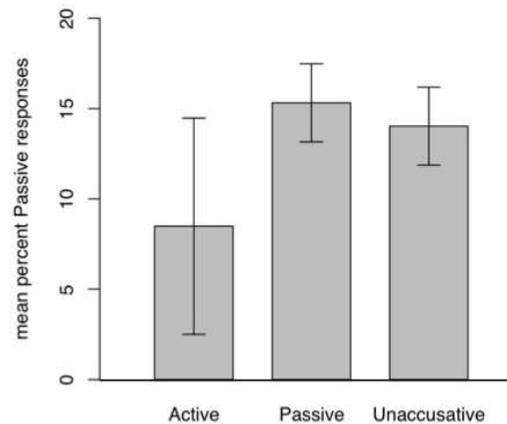


Figure 1. Percentage Passives in Experiment 1, by Prime Type.

The difference between Passive Primes and Unaccusative Primes was not significant (difference in means = 1.30; 95% family-wise confidence interval (-3.86,6.45)). Paired t-tests with correction for multiple comparisons confirmed these results: Passive Primes vs. Active Primes ($T=3.07$, $df=43$, corrected $p<0.02$), and Unaccusative Primes vs. Active Primes ($T=2.65$, $df=43$, corrected $p<0.05$) were significantly different. The Passive Primes vs. Unaccusative Primes contrast was non-significant ($T=0.60$, $df=43$, corrected $p<0.6$).

2.3 Discussion

Experiment 1 replicates results of previous studies (Bock and Loebell 1990; Bock and Griffin 2000) by showing that passives prime subsequent production of passives. In addition, unaccusatives were as effective as passives at priming passive structure; that is, more passives than actives were produced as picture descriptions when an unaccusative sentence had been produced in the previous trial. If what's being targeted by this experimental paradigm is truly structural similarity, the unaccusative-to-passive priming suggests that these superficially different sentence types nevertheless share some syntactic property, to the exclusion of actives. But maybe the effect in Experiment 1 isn't due to syntactic priming at all. In fact, Melinger (2006) reports similar data (unaccusative-to-passive priming), and attributes the effect to thematic—not structural—overlap, since both unaccusatives and passives have Theme subjects. (Though probably not coincidental, it is a fact about English and many other languages that syntactic and thematic structure typically align with each other.)

There is evidence for thematic priming independent of syntactic structure: Chang, Bock & Goldberg (2003) looked at 'spray/load' verbs, which exhibit an alternation that (superficially) maintains syntactic structure while changing the order of thematic roles (e.g. *The man sprayed wax on the car* (Theme *wax* > Location *the car*) versus *The man sprayed the car with wax* (Location > Theme)). They found that Theme>Location primes were followed by more Theme>Location target utterances than Location>Theme ones, leading them to conclude that there was an effect of thematic priming independent of syntactic structure. Since thematic and syntactic structure are confounded in the Experiment 1 materials, the possibility that part or all of the Unaccusative-to-Passive priming effect was due to thematic overlap can't be excluded.

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This might be a good time to step back and consider what source(s) of priming could be at work in Experiment 1. Here are some fairly obvious candidates. First, unaccusatives and passives might differ from actives in that they have derived subjects—actives, on the other hand, preserve what we might call the base or canonical argument order. This would be a “structural” option. Second, unaccusatives and passives have Theme subjects, while actives have Agent subjects; as such, the Experiment 1 results could be due to thematic priming. Third, only actives have (surface) direct objects: the single argument of an unaccusative verb ends up in subject position, and when there is a post-verbal argument in a passive structure, it appears in a by-phrase (regardless of its adjunct status, the preposition is non-optional). A first step in distinguishing the options laid out above is looking at structural priming in case where syntactic structure doesn't parallel thematic structure. Experiment 2 uses psych verbs as a way to get around the confound present in Experiment 1.

3. Experiment 2: Passive priming with Psych verbs

One case where thematic roles do not align with agent-theme transitive verbs are the causer-experiencer variety of psych verb. While passivized agentive verbs have Theme subjects (8a), passivized causer-experiencer verbs have Experiencer subjects (8b).

- (8) a. Abby pinched her sister / Abby was pinched by her sister
b. Abby frightened her sister / Abby was frightened by her sister

For Experiment 2, the important comparison will be whether the Passive Causer-Experiencer primes are followed by more passive picture descriptions to the same extent that the Passive Agent-Theme primes are followed by more passives: such a result would not be attributable to thematic structure overlap from prime to target, since passives with an Experiencer subject (and a by-phrase Causer) would be priming passives with a Theme subject (and a by-phrase Agent). While previous research (Chang, et al 2003) has obtained similar results suggesting that thematic and structural priming both occur independently of each other, the experiment outlined above would potentially confirm the Chang et al finding with a different class of verbs, whose syntactic properties have been studied extensively (Belletti and Rizzi 1988; Pesetsky 1987; others). Psych verbs also have one possible advantage over spray/load verbs (used in Chang et al's study): because the preposition that appears in spray/load-alternating verbs is usually one of a very restricted set (*onto*, *into*, *on*, *around*), there's a possibility that the lexical repetition contributed to the priming effect. While other problems may arise with psych verbs—in particular, with the preference for stative as opposed to eventive readings—they won't introduce any lexical regularities of the type described.

3.1 Methods

Participants. Subjects for the experiment were undergraduate students from UCLA. 37 monolingual native speakers of American English participated. They received either credit toward fulfilling a requirement in an introductory linguistics course, or \$8, for their participation. None of the subjects had participated in Experiment 1.

Materials. There were 48 black and white pictures depicting transitive events, as in Experiment 1. There were 12 Active Causer-Experiencer sentences, 12 Passive Causer-Experiencer sentences, 12 Active Agent-Theme sentences, and 12 Passive Agent-Theme sentences, making a total of 48 primes. Sentences were digitally recorded at a sampling rate of 44kHz by a male native speaker of North American English. Fillers were the same as in Experiment 1.

Design. The experiment crossed Prime verb type (Causer-Experiencer vs. Agent-Theme) and Prime structure (Active vs. Passive), as shown in Table 4. Each subject saw 12 prime sequences from each of the 4 cells of the experiment. The dependent measure was the percentage of Passive responses of all codable responses in a particular condition.

		Prime verb type	
		<i>Causer-Experiencer</i>	<i>Agent-Theme</i>
Prime structure	<i>Active</i>	<i>'The protesters were frightening the bystanders'</i>	<i>'The babysitter was feeding the children'</i>
	<i>Passive</i>	<i>'The bystanders were being frightened by the protesters'</i>	<i>'The children were being fed by the babysitter'</i>

Table 4. Experiment 2: Prime verb type x Prime structure.

Four lists were created, all containing 12 primes for each of the 4 experimental conditions in random order; each of the four lists was paired with a different randomly ordered list of target pictures, to generate four fixed lists with different prime-target pairings. Active and passive versions of the primes were counterbalanced across lists. Filler items were drawn from the same list of fillers in random order.

Procedure. The procedure was the same as in Experiment 1.

3.2 Results

Responses were coded as in Experiment 1. Mean percentages of Passive responses by condition are given in Table 5.

		Prime verb type	
		<i>Causer-Experiencer</i>	<i>Agent-Theme</i>
Prime structure	<i>Active</i>	7.2 (10.4)	11.6 (13.8)
	<i>Passive</i>	12.8 (13.5)	17.5 (12.2)

Table 3. Experiment 2 results: mean percentage Passive responses (standard deviation).

Analysis of variance was performed separately with subjects and items as random effects. In the subjects analysis there was a main effect of Prime structure ($F(1,37) = 6.26, p=0.01$), and of Prime verb type ($F(1,37) = 4.01, p<0.05$). There was a main effect of Prime structure ($F(2,146) = 4.71, p<0.05$), but not of Prime verb type ($F(2,146) = 1.19, p>0.2$) by items. The Prime structure by Prime verb type interaction was non-significant by subjects and by items ($F_1, F_2 < 1$). Planned comparisons revealed that more Passives were produced after Passive primes than after Actives, for both Agentive verbs ($T=2.54, df=29, p<0.02$) and Psych verbs ($T=2.02, df=29, p=0.05$). Mean percentage of Passive responses by condition are shown in Figure 2.

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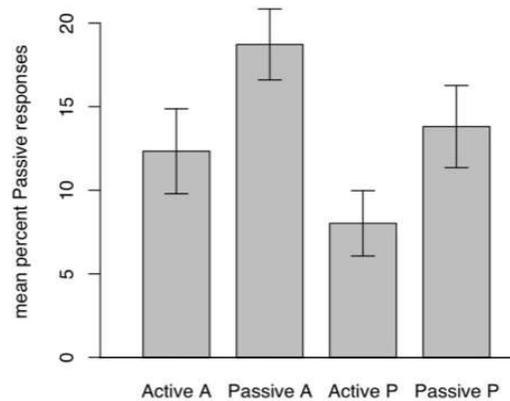


Figure 2. Percentage Passives in Experiment 2, by Prime Type (A = Agentive, P = Psych verb).

Interestingly, other factors related to the target pictures turned out to be reliable indicators of utterance form. Responses were further sorted by: (1) Argument pair type—whether the target picture showed two humans (HH), two non-human animates (AA), an animal and a human (AH), or two inanimates (II); and (2) Event type—whether the target depicted a 'violent' event (V, e.g. a scary-looking pit bull jumping on a mailman) or a 'non-violent' event (NV, e.g. a girl poking a sleeping man's shoulder). The category means are given in Table 4.

Argument pair type		Event type	
Human-Human	9.73	'Non-violent'	9.27
Animate-Animate	6.49	'Violent'	21.47
Animate-Human	21.82		
Inanimate-Inanimate	22		

Table 4. Experiment 2: mean percent Passive responses by Argument pair type, Event type.

A stepwise regression was performed to discover the relative contributions of Prime structure (active/passive), Prime verb type (agentive/psych), Argument pair type (HH/AA/AH/II), and Event type (V/NV). Argument pair type turned out to be the best predictor of utterance form, followed by Event type, then Prime structure.

3.3 Discussion

The main result of Experiment 2 suggests that passive priming can't be due solely to thematic structure, since priming is observed both from Agent-Theme verbs to other Agent-Theme verbs (where there is both structural and thematic overlap) and from Agent-Theme verbs to Causer-Experiencer verbs (where there is structural but not thematic overlap). Since there was no Unaccusative prime condition in Experiment 2, this result in itself does not rule out the possibility that thematic priming contributed to the Unaccusative-to-Passive priming in Experiment 1. But the presence of structural priming without overlapping thematic structure in Experiment 2 suggests that the priming in Experiment 1 could be due to syntactic structure.

In addition, the animacy/humanness pairings of event participants, and the 'violentness' of the event depicted in the target proved to be good predictors of utterance form. This is of course not surprising, since there is much existing work on the animacy hierarchy, and the importance of factors like affectedness in modulating surface word order—in particular what items are likely to be realized as subjects (see e.g. Keenan and Comrie 1977; Tomlin 1983; Aissen 1999; for animacy/humanness effects in sentence production: Bock 1986b; Bock, Loebell and Morey 1992).

5. General discussion

Earlier in the paper, we considered the following as possible sources of Unaccusative-to-Passive priming: (1) that unaccusatives and passives have derived subjects, while the surface form of actives preserves the base or canonical argument order; (2) that unaccusatives and passives have Theme subjects, while actives have Agent subjects (for Agent-Theme verbs, at least), and (3) actives, but not passives or unaccusatives, have direct objects. Regarding (2): while the second experiment presented doesn't include unaccusatives and therefore cannot rule out the possibility that some amount of thematic priming was at work in Experiment 1, it does show that priming of passive syntax does not depend on thematic structure. None of the current experiments compare unaccusatives and unergatives, but Melinger (2006) has shown that unaccusatives prime passive structure while unergatives don't, ruling out the lack of a direct object as a plausible source of priming.

The experiments presented in this paper suggest that structural priming—a behavioral phenomenon observed in sentence production—is sensitive to syntactic properties that are not necessarily preserved in surface form. This in turn suggests that whatever level of representation encodes common syntactic structure for unaccusatives and passives (and distinguishes unaccusatives from unergatives) is one that is accessible to the sentence production machinery as we generate sentence structures for use. Thus, while it's conceivable that for purposes of sentence production, speakers use templatic frames that look much like constructions, Unaccusative-to-Passive priming suggests we're able to access structural representations of a non-surfacy type when we make use of certain types of verbs. Importantly, whatever the exact mechanism turns out to be, structural priming is not a process restricted to syntactic alternations of the same number and type of arguments, but rather one that targets structural similarity of a broader type not limited to particular instances of alternations or constructions.

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