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Structural Priming and Non-surface Representations

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by

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ABSTRACT OF THE THESIS

Structural Priming and Non-surface Representations

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Syntactic theories differ on how surface syntactic forms are generated—in particular, different assumptions are made about the nature of lexical representations, and how lexical information maps onto syntactic structure. This work addresses a related (but in principal different) question from the point of view of sentence processing, namely: what types of structural information are relevant in building sentence structures for production? The results of two sentence production experiments are presented that use a picture description paradigm to look at structural properties of passives. Specifically, structural priming (Bock 1986; Potter & Lombardi 1990, 1998; Bock & Griffin 2000; many others) is used as a way to detect underlying structural similarity across verb/sentence types that have different surface structural realizations. Experiment 1 replicates previous findings of passive priming in active-passive pairs. Experiment 2 shows a priming effect from unaccusative primes to passive targets, suggesting that—despite the superficial dissimilarity between unaccusative sentences and passive sentences with respect to verbal morphology and number of arguments--these two sentence types share some property that is accessed during sentence production. While one interpretation of this finding is that unaccusatives and passives have similar structure at some level of representation, other plausible explanations are discussed; in particular, possible future experiments are outlined that will be able to deconfound syntactic and thematic structure.

1.   *Introduction.*

This study has at its center a theoretical question about the nature of syntactic representations, and ultimately seeks to relate the experimental findings reported here to a theory of how syntactic structures are generated.   Specifically, I'm interested in how phrase- or sentence-level alternations are related: at what level of representation do alternate syntactic forms share structure, and what is the nature of the operation that results in the different surface realizations? To illustrate with a simple example, it has long been acknowledged that sets of sentences like the following must be related to each other by some kind of rule or transformation.

(1)   a.   Abby kicked Sue
        b.   Sue was kicked by Abby

(2)   a.   The children showed the drawing to the teacher
        b.   The children showed the teacher the drawing

The descriptive generalization is that (1b) and (2b) encode the same thematic relations as their (a) counterparts—in (1), Abby is the kicker and Sue is the 'kickee', and in (2), the drawing is being shown to the teacher in both sentences. These alternations (Passive in (1), Dative Shift in (2)) are not item-specific: Passive is generally available regardless of choice of lexical item, and although Dative Shift is to some extent lexically restricted, there is still a class of ditransitive verbs that systematically participate in this alternation.   For considerations of parsimony, it seems desirable to represent these pairs just once, and derive one of the sentences from the other. The disagreement is about where exactly these alternate structures share a common representation, and what this common representation is.

This question is addressed empirically here using a phenomenon known in the psycholinguistics literature as structural priming (also: syntactic priming, or structural/syntactic persistence). The most basic and general description of structural priming is as follows: 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. 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 (3). Likewise, as in (4), a prepositional dative sentence was more likely to be followed by another prepositional dative sentence than a double object sentence was.

(3)   a.   The boy gave the girl a present (prime)
         b.   The student showed the teacher a drawing (target)

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

Even before this study, however, early observational reports—including Weiner and Labov (1983) and Estival (1985)—suggested that there is a tendency toward matching structural properties of sentences produced as part of a discourse[1].

What does such a behavioral effect in sentence production really show about how alternating structures are generated by a speaker? The reasoning behind these studies is roughly as follows: priming is a relation between similar things—exposure to a prime facilitates response to a subsequent target when prime and target match on some relevant property (see e.g. Tulving and Schacter 1990). At face value, then, structural priming suggests that the syntactic structures of two sentences or sentence types are related, by showing that producing one facilitates subsequent production of the other. Together with a theory of the priming mechanism, 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 a structural (i.e. syntactic) representation.

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1   See Pickering and Garrod (2004) for a recent theory which attributes structural priming-type effects in discourse to speaker-hearer alignment.

Such theories treat structural priming either as facilitation due to recency of activation (Roelofs 1992, 1993; Pickering and Branigan 1998), or as a form of implicit learning (Chang, et al 2000; Bock and Griffin 2000). Both types of models make use of activation networks that represent phrasal constituents as nodes; where they differ is in the source of structural priming effects. Residual activation theories rely on the decay of activation over time, along with the number of links in the network that need to be traversed by spreading activation, to differences in the magnitude of priming effects. Pickering and Branigan (1998) develop such a model (extending the spreading activation model in Roelofs 1992, 1993), in which the lemma-level representation of a verb is linked to nodes encoding combinatorial information—essentially, subcategorization frames (e.g. 'NP_NP' and 'NP_PP' for a dative alternating verb). Syntactic priming is explained as an effect of residual activation of a combinatorial node: using a particular verb (in a particular syntactic configuration) will activate the verb node and a combinatorial node, and if a subsequently selected verb is linked to that combinatorial node, it will be more likely to be selected due to leftover activation[2].

In contrast, in implicit learning models of priming, language experience continuously modulates weights between nodes in the network, in effect changing baseline levels of activation for particular nodes[3]. According to such a theory, priming effects should last longer than expected based on decay of activation over time. Bock and Griffin (2000) argue for an implicit learning mechanism based on structural priming effects that

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2 Melinger and Dobel (2002) argue for a residual activation-based priming mechanism based on finding structural priming from single-verb (as opposed to full-sentence) primes. The reasoning is that a mechanism that adjusts message-to-structure connection weights (i.e. implicit learning-type models) wouldn't, according to the authors, be able to account for lexically-driven structural priming. Their findings are however consistent with an account which allows for lexical effects, but additionally allows for strengthening of message-structure connections; in such an account, what have been lumped together as 'structural priming' effects have multiple potential sources, including lexically-specified morphosyntactic features and connection weights in the message to structure mapping.

3 In the sense of procedural or motor learning as characterized in other domains (Seger, 1994; a.o.).

persisted across up to 10 intervening trials, and in light of the observation that repetition priming due to residual activation in other domains (e.g. lexical priming) tends to be short-lived[4].

Because the experiments in this paper only look at priming between elements over short (single-item) lags, or between adjacent elements, they won't help decide between transient activation and implicit learning models. I assume only that surface forms that have a common structural representation at some level can prime each other; in other words, if one sentence type can be shown to prime another, this will constitute evidence that these sentence types share some structural property. The goal of this study is not to explain how structural priming occurs, but rather to use it as a tool to probe abstract structural representations; in this respect it is like most other psycholinguistic studies, which seek to establish properties of particular kinds of priming while remaining agnostic about the mechanism involved. That said, it is important to note that an explanatory account of structural priming will have to ultimately provide a mechanism to combine with the right theory of lexical and syntactic representations.

The organization of this paper is as follows: first, I survey the relevant findings in the psycholinguistic literature on structural priming, and outline some of the longstanding debates surrounding the passive construction, explaining why passivization is an important testing ground for syntactic theories that differ on how surface syntactic forms are generated. Two picture description experiments are presented which use structural priming to compare passives to unaccusatives, which on some accounts are structurally related to passives. Experiment 1 replicates previous findings of structural priming in active-passive pairs. In Experiment 2, both passive and unaccusative sentences are shown to prime

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4   See also Chang, Dell, Bock and Griffin (2003), for a Connectionist model. Kaschak, Loney and Borreggine (2005) argue for an implicit learning mechanism based on cumulative structural priming effects (over up to 20-trial blocks), the idea being that residual activation would decay too rapidly to ever yield cumulative priming effects across many trials.

passive sentences, providing support for a theory in which passives and unaccusatives share some property that excludes active sentences. While these results are compatible with the structural priming hypothesis being tested here, other potential sources of priming, and how they bear on the process of structure building in production, are discussed.

1.1. *Structural priming.*

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; Potter and Lombardi 1990, 1998; Fox Tree and Meijer 1999; 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 Fox Tree and Meijer 1999; Potter and Lombardi 1990, 1998; 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 (5a), where 'the church' is a

location/destination, were shown to prime sentences like (5c), where 'the boy' is a goal, as much as (5b) does, where 'the church' is a goal.

(5)   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: (6a) does not prime (6c), while (6b) does.

(6)   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)

Another potential source of priming is functional or closed-class elements. Closed-class immanence refers to the hypothesis that functional items have a special status in sentence processing; the general claim is that functional elements are associated with pieces of syntactic structure. Hypotheses of this kind have been invoked in language comprehension (Kimball 1973), acquisition (Gleitman and Wanner 1982), and production (Garrett 1980). In sentence production, much of the evidence for something akin to closed-class immanence has come from the distribution of speech errors (Garrett 1980, 1982): not only do closed-class items rarely participate in sound errors, there is a strong tendency for exchanges of open-class elements to be "stranding exchanges"—an exchange involving word stems where the inflections are stranded in place, as in *She's already packed two trunks* → *She's already trunked two packs* (Garrett 1975). Bock (1989) tests a version of this hypothesis, namely, that overlap in functional elements and syntactic structure will have independent, additive priming effects on subsequent utterances. It is assumed that prepositions are closed-class elements, and therefore that the prepositional forms of dative (*The secretary is taking a cake to her boss*) and benefactive (*The secretary is baking a cake*

for her boss) sentences differ in one functional element but not in surface constituent structure. If functional items and syntax have additive priming effects, *to*-datives should be followed by a higher proportion of dative picture descriptions than *for*-datives (benefactives); however, no difference was found in the magnitude of priming—*to*-datives and benefactives primed *to*-datives equally well[5].

Another way in which the *to*-datives and benefactives differ is in the thematic role assigned to the PP argument; using the example above, *to her boss* is a Goal/Location, whereas *for her boss* is a Beneficiary. On the one hand, the lack of structural priming due to closed-class elements still stands: if functional items like *to* and *for* were a source of structural priming, *to*-datives would follow *to*-dative primes more often than benefactive primes (likewise for benefactives) regardless of non-overlap of thematic structure. But the observation that mismatching thematic structure does not affect structural priming is reminiscent of Bock's (1986b) finding that the magnitude of structural priming does not differ depending on overlapping thematic roles; that is, there seems to be no added priming benefit due to matching thematic structure. Another result along these lines is that locative by-phrases (*The plane landed by the tower*) prime passive by-phrases (*The plane was landed by the pilot*) as well as passive by-phrases (*The exam was written by the professor*) (Bock and Loebell 1990). I will return later to the question of thematic structure and its relation to syntactic structure—a problem in trying to isolate a potential effect of thematic roles on surface structure is that, at least in English, thematic structure and surface syntax are highly confounded. For the moment, the overall picture seems to be that there is priming of syntactic structure of the most 'superficial' type: sentences that differ in thematic/argument structure have been shown to prime each other when they share subcategorization frames.

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5 V. Ferreira's (2003) finding that mention of the complementizer *that* does not prime subsequent use of *that* also suggests that functional (closed-class) elements don't prime.

1.2. Passive.

1.2.1. The 'passive transformation'.

Early treatments of passives accounted for the systematic word order differences between actives and passives by simply building them into a transformational rule, like the one in (7), taken from Chomsky's *Aspects of a Theory of Syntax* (1965). The input to the rule is any sentence that matches the structural description (SD) on the left-hand side of the arrow; the rule promotes the post-verbal NP to pre-verbal position, supplies the passive auxiliary 'be', adds passive participial morphology to the main verb, and removes the pre-verbal NP from subject position, optionally placing it in a post-verbal 'by'-phrase[6].

(7)   X - NP - AUX - V - NP - Y - *by* - Z
     SD: 1   2   3   4   5   6   7   8 →
     SC: 1   5   3+*be* 4+*en* Ø   6   7+2 8

The rule in (7) covers many cases, but two things in particular were thought to be particularly problematic; both have to do with missed generalizations.

First, 'V' is written right into the structural description of the rule. This is fine for most cases of passive, which do involve verbs, but what about nominalizations? As it is, (7) can account for active-passive pairs like (8a-b), but leaves nominals like (8c-d) out in the cold. The generalization that (8c-d) ought to be related in exactly the way that (8a-b) are is simply missed.

(8)   a.   The enemy destroyed the city
          b.   The city was destroyed by the enemy
          c.   the enemy's destruction of the city

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6 Note that '*by*' is written into the structural description of the passive rule in (7)--this is simply shorthand. In *Aspects*, the position occupied by '*by*' is a Manner adverbial optionally included in the VP; one realization of the Manner adverbial is '*by*—passive', where 'passive' is a filled by the first NP (yielding *7+2* in the structural change line in (7)).

8

d.   the city's destruction by the enemy

A related point that was brought to light was the unexplained variability in verbs and the morphology that appeared on their 'derived nominal' counterparts. To take an example: why should verbs like 'destroy' and 'confuse' have nominalized forms 'destruction' and 'confusion', while 'refuse' corresponds to 'refusal' (cf. *'refusion', *'refusement'), and 'amuse' becomes 'amusement' (cf. *'amusion', *'amusal')? These observations gave rise to the so-called Lexicalist Hypothesis, in particular the encoding of item-specific restrictions of the type just described in lexical redundancy rules. In addition, the innovation of X' theory allowed for parallels to be captured between verb/noun and sentence/nominalization pairs (Chomsky 1970). In this new system, passive got "modularized": it was broken up into separate processes of NP-preposing and NP-postposing; some things became the responsibility of lexical subcategorization (e.g. passive morphology on the verb, the passive auxiliary), and there had to be a separate semantic process that made sure the subject NP in a passive was interpreted as the patient, while the NP in the by-phrase was interpreted as the Agent or Experiencer.

The second seemingly missed generalization—going back to *Aspects*—was that NPs were always being moved to places where NPs normally occurred. This is just built into the rule as it's stated in *Aspects*, but we don't in fact see similar transformations involving movement of NPs to non-NP positions, as in (9).

(9)   a.   Bill has __ been stalking Mary → *Bill has Mary been stalking __
       b.   The enemy __ completely destroyed the city →
               *The enemy the city completely destroyed __

Such observations led Emonds (and others) to develop the idea of structure preservation—that is, that the observation about possible targets of NP-movement was part of a more general (universal) constraint on possible transformations. More broadly, movement

operations were classified based on properties shared with other transformations. For instance, while certain transformations—like passive—are structure-preserving and clausebound (monocyclic), others, like wh- movement, are unbounded and only affect the root node. But if what was previously thought of as a unitary 'passive transformation' was now to be thought of as separate applications of the more general operation ('NP-movement'), how can one be 'specific' enough to state properties that passive sentences share with each other but not with other supposed instances of 'Move NP'?

1.2.2. *UTAH and Theta theory.*

What are the 'characteristic properties' of passives, exactly? Passive morphology, for one thing: passive sentences always contain the passive auxiliary ('be' in English), along with the main verb in participial form. The argument that appears in subject position in an active sentence surfaces in a by-phrase adjunct[7]. In addition, the surface subject of a passive has properties derived from some post-verbal argument in its active counterpart[8]. Notice that it isn't always the direct object that is promoted to subject position (Marantz 1984, and others): consider the following pairs/triples, where the (b-c) sentences are passive versions of the (a) sentences.

(10) a. Abby showed the book to Ted
      b. Ted was shown the book (by Abby)
      c. The book was shown to Ted (by Abby)

(11) a. The grad students argued for that solution to the problem
      b. That solution to the problem was argued for by the grad students

(12) a. Tim always takes advantage of Dan's photographic memory
      b. Dan's photographic memory is always taken advantage of (by Tim)
      c. Advantage is always taken of Dan's photographic memory (by Tim)

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7   Buf cf. Collins (2005), who proposes that by-phrase are base-generated in VP-internal subject (i.e. argument) position.

8   This isn't strictly speaking true of all passive subjects, if *there*-insertion sentences like *'There were three men arrested'* are to be considered passives. These sentences still have the property that the internal argument of the main verb is displaced to a pre-verbal position.

(13) a. Dan expects to appear to have returned Ted's car by tomorrow
      b. Ted's car is expected to appear to have been returned by tomorrow
          (by Dan)

How can we express this last generalization ('the surface subject of a passive has properties of some non-subject argument in its active counterpart') more precisely? It's convenient to be able to refer to theta roles: take (14) as a starting point in describing the characteristic meaning relationship between active-passive pairs.

(14) In a passive, the 'patient' argument of the active counterpart appears in surface subject position, while the 'agent' argument appears optionally in a by-phrase adjunct.

One conceptually compelling theory about how information in lexical entries, underlying syntactic structure, and surface structure are related is the Uniformity of Theta Assignment Hypothesis (UTAH) (Baker 1988)[9]. The basic insight is that the ordering of thematic roles is non-random crosslinguistically—in fact, it seems to be highly systematic, with deviations from canonical ordering showing characteristic properties (i.e. of displacement). A theory like UTAH builds a thematic hierarchy into the grammar (universally), and crucially associates particular thematic roles with unique syntactic positions in underlying structure. This has the effect of allowing the theory to eliminate linking information from the lexicon entirely, and is in this respect a huge simplification—none of the argument structure idiosyncracies need to be represented anywhere in the lexicon anymore. The

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9 The original formulation of UTAH (Baker 1988, p. 46)):

(i) *The Uniformity of Theta Assignment Hypothesis*:
     Identical thematic relationships between items are represented by identical structural relationships between those items at the level of D-structure. (=(30))

While there are many versions of UTAH—or the weaker Universal Alignment Hypothesis (UAH)—floating around, these all share the idea that there is some language-general principle which determines how arguments bearing particular thematic roles map onto syntactic structure. Theories under which thematic roles are intrinsically ordered according to prominence include Grimshaw (1990); Gruber (1965); Jackendoff (1972, 1987).

price is that such a system puts on the syntax the non-trivial burden of getting the correct surface argument order.

Going back to (14), we can see that it's too specific as is: consider the following cases where the surface subject of the passive sentence isn't a 'patient', or the argument appearing in the by-phrase isn't an 'agent'.

(17)   a.   Meredith received the package
           b.   The package was received by Meredith (Meredith = 'goal')

(18)   a.   Those students absolutely hate/resent/adore the TA
           b.   The TA is absolutely hated/resented/adored by those students (those students = 'experiencer')

(19)   a.   The director marched the band across the stadium
           b.   The band was marched across the stadium by the director (the director = 'causer', the band = 'agent')

(20)   a.   The coach ran the crew team up and down the stadium steps
           b.   ?The crew team was run up and down the stadium steps by the coach (the coach = 'causer', the crew team = 'agent')

Some accounts of passive (starting with Chomsky's (1981) Lectures in Government and Binding; others include Jaeggli 1986; Baker and Collins 2003; Lasnik 1988; Baker, Johnson and Roberts 1989) get the right surface structures for passives without reference to particular theta roles by specifying properties of the passive morpheme *-en* as in (21).

(21)   a.   *-en* absorbs Accusative case
           b.   *-en* absorbs the external theta role

Such an account tries to bundle several properties of passives—namely, verbal morphology, non-assignment of the external theta role, and unavailability of accusative case in the typical "accusative-case position"—by linking them all to the passive participial morpheme. Some independently needed principle like the Case Filter, the Visibility Condition on NPs, or the External Projection Principle (EPP) will then ensure that the un-

case-marked post-verbal argument will raise to subject position, where Nominative case is available.

If one were to take the strictest possible interpretation of UTAH, it would seem that an analysis assuming some version of (21) must violate UTAH, since theta role assignment happens differently for actives and passives. However—as Baker (1997) notes in a footnote—Baker (1988) doesn't in fact implement this strict version of UTAH. Instead, "identical structural relationships" is interpreted as something like "equivalent structural relationships": in Baker's analysis of passives, the Agent role is assigned to the functional head containing the morpheme *-en* in passive sentences, while it is assigned to the specifier of IP in active sentences. While these are not identical structural relationships, they could arguably be "equivalent" (both positions are external to VP, but within the smallest IP dominating VP).

1.2.3. *Lexical passive*.

There are of course other ways to simplify the grammar—another major approach to passive can be found in a framework like Bresnan's Lexical Functional Grammar (LFG) (Kaplan and Bresnan 1982; Bresnan 1982). Word order alternations—passive, for one— are built into the lexicon in the form of lexical rules (in other words, not derived in the syntax). Such a system greatly reduces the number of operations the syntax has to perform in order to derive the correct surface string. Instead, a bunch of lexical processes are put to work to derive various verbal (or nominal) forms from their 'root' forms; in fact, one could think of this as an extreme form of the familiar lexicalist hypothesis. A key argument for passivization being a lexical rule has to do with rule-ordering with respect to Adjective Conversion (Bresnan 1982; Lieber 1992). Formation of adjectival passives is argued to be a lexical process fed by passivization, based on the observation that the adjectival forms

have all the item-specific properties of the passive participles[10]; for instance, you get *a broken heart*, not **a breaked heart*, and *unsung hero*, not **unsinged hero.* Further, Adjective Conversion seems to apply exclusively to those intransitive participles that have Themes as subjects: *a fallen leaf* (unaccusative), *a lapsed Catholic* (perfect participle), *a recently-given talk* (passive participle), but not **a napped baby* (cf. The baby napped) or **an eaten child* (cf. The child ate (something))[11]. On the other hand, Wasow (1977) argues that the input to adjectival formation is the root form of a verb, not the participle—if his argument holds, this one doesn't, but the participial allomorphy becomes entirely coincidental.

One crucial difference between a derivational system and a lexicalist system is that, in the former, an important requirement of derivations is that they happen mechanically— any constraints on movement, derivations, or representations must be non-specific properties of the syntax that should hold across constructions and across lexical items, and are expected to vary parametrically across languages. It's not clear that the same holds of lexical rules: what constrains a lexical rule such that it won't generate structures not attested in the language in question?

For all the above considerations, passive seems to be a good testing ground for some of the really divisive questions about the organization of the lexicon, the domain of syntactic operations, and the relationship between the lexicon and syntax. This is a case where the typical order of thematic roles (as represented in the lexicon, and perhaps in underlying structure, if some version of UTAH is right) is reversed; as such, if there were

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10 There are a couple exceptions to this generalization, where the adjectival participle does not match the passive participle: *a sunken ship* vs. *the ship was sunk/*sunken*, *a burnt waffle* vs. *the waffle was burned/*burnt*, *molten copper* vs. *the copper was melted/*molten*. The only thing I have to note about these cases is that every such verb I can think of happens to also participate in the causative/inchoative alternation. Not all verbs of this class have mismatching participial forms: t*he broken vase* vs. *the vase was broken*, *the evaporated water* vs. *the water was evaporated* (*the ?spilled/?spilt milk* vs. *the milk was spilled/*spilt*).

11 Most examples in this section are from Bresnan (1982).

some means to detect properties of underlying syntactic structure, it might also be possible in principle to pinpoint the locus of certain alternations, like passivization.

The reasoning behind the experiments in this study is as follows: structural priming —whatever cognitive mechanism it involves—is supposed to detect structural similarity. The strategy will be to find some verb type or construction for which there are theoretical motivations to think it is syntactically similar to passives, and ask whether this other verb type is able to structurally prime passive sentences. The next section discusses a couple such cases, focusing on unaccusatives, which will figure in Experiments 1 and 2.

1.3.   *Unaccusativity.*

1.3.1. Properties of unaccusatives, and the Unaccusative Hypothesis.

Before we get to unaccusatives, a few comments about the middle voice. Middles share with passives the property that a non-agent/theme/patient argument appears in surface subject position, making it another probable instance of 'NP-movement'.

(22)   a.   Sue cut/is cutting the bread (active)
       b.   The bread was cut/is being cut (by Sue) (passive)
       c.   The bread cut/cuts easily (with a sharp knife) (middle)

(23)   a.   The students are reading the article (active)
       b.   The article is being read by the students (passive)
       c.   The article reads quickly (by smart students) (middle)

They differ from passives in that the main verb appears with active morphology, and they tend to sound better (sometimes require) manner adverbs that lend them a generic reading —that is, a single-event reading is generally unavailable with middles in the present tense. (Note that the manner adverb seems to be required even when an eventive reading is brought out by putting middles in the past tense, as in *The article read *(quickly)*.)

Like middles, unaccusatives have been argued to share syntactic properties with

passives; unlike passives and middles, however, 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 actives[12]. 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 lexicon[13]. 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 (23).

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

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12 This 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.

13 See Grimshaw (1979, 1981) on the lexical representations of verbs; Grimshaw 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.

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 (23a)), while unaccusatives have a single internal underlying argument (as in (23b)). (24) represents these configurations while also taking into account the VP-internal subject hypothesis (Koopman and Sportiche 1991).

(24)   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.

1.3.2 *Detecting Unaccusativity.*

While there isn't one clean test for determining whether or not an intransitive verb is unaccusative, there is an array of diagnostics that can be broadly classified into two types. The first consists of tests which depend on the argument of an unaccusative verb remaining in post-verbal position; presumably what happens is that movement to surface subject position is somehow blocked, forcing the argument to remain in its base-generated position (or somewhere near it). These are referred to by Levin and Rappaport (1995) as diagnostics of 'surface unaccusativity.' 'Deep unaccusativity' diagnostics don't care about the surface realization of arguments—they seem to hinge on semantic properties of the verb in question. An illustrative (but non-English) example of these types of diagnostics is ne-cliticization as opposed to auxiliary (*avere*/*essere*) selection in Italian. (25) and (26) illustrate the *ne*-cliticization test for unaccusativity in Italian.

(25)   a.   Molti esperti arriveranno

many expert arrive-FUT

b. Arriveranno molti esperti
arrive-FUT many expert
Many experts will arrive.

(26) a. Ne arriveranno molti
CL arrive-FUT many

b. *Molti ne arriveranno
many CL arrive-FUT
Many of them will arrive.
(Burzio 1986)

(25) shows that the single argument of 'arrive'—*molti esperti*—can appear either pre-verbally or post-verbally; (26) shows an asymmetry between the pre-verbal and post-verbal cases: ne-cliticization is only possible for post-verbal arguments, suggesting that the pre-verbal argument in (25a) is in a derived position, while the post-verbal argument in (25b) is base-generated post-verbally. This type of diagnostic contrasts with auxiliary selection, illustrated in (27) and (28).

(27) a. Gianni a/*è telefonato
Gianni has/is called

b. A/*È telefonato Gianni
Has/Is called Gianni
Gianni has called.

(28) a. Gianni è/*a arrivato
Gianni is/has arrived

b. È/*A arrivato Gianni
Is/Has arrived Gianni
Gianni has arrived.

Note that the surface position of the argument 'Gianni' doesn't affect the outcome of the test: the (a) and (b) sentences pattern together. (27), which contains an unergative verb, selects the auxiliary 'have', and (28), which contains an unaccusative verb, selects 'be'.

How do we tell intransitive verbs apart in English? According to Levin and Rappaport, the only diagnostics for surface unaccusativity in English are there-insertion and locative inversion. There-insertion seems to be possible with unaccusative verbs, as in (29), but not with unergatives, as in (30).

(29) a.   There appeared a messenger at the door
      b.   There remained four children in the room

(30) a.   *There ran two kids in the parking lot
      b.   *?There slept a cat on the water cooler

This test is analogous to Italian ne-cliticization; the logic is that the dummy argument (i.e. non-theta-role-bearing) 'there' can be inserted in subject position only when the thematic argument is base-generated post-verbally, suggesting that the immediately post-verbal NPs in (29) are generated post-verbally, while the ones in (30) are not[14].

Another indicator of unaccusativity, under some accounts, is participation in the Causative-Inchoative alternation, exemplified in (31)-(32).

(31) a.   The ice cream melted (inchoative)
      b.   The sun melted the ice cream (causative)

(32) a.   The vase broke (inchoative)
      b.   The child broke the vase (causative)

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14 Locative inversion works similarly:

(i)   a.   At the door appeared a messenger
      b.   In the room remained four children

(ii) a.   *?In the parking lot ran two kids
      b.   ??On the water cooler slept a cat

Inversion only seems to be possible with unaccusative verbs—that is, in cases where the argument is base-generated in an 'internal argument' position. Unexpectedly, however, there seem to be some supposedly unergative verbs that are just fine with locative inversion:

(iii) a.   Into the room walked a man
      b.   Out of the basket jumped two frogs

A simple hypothesis about why such pairs exist is that in the intransitive (inchoative) versions, the argument that surfaces as the subject is underlyingly an internal argument of the verb, just as it is overtly in the transitive (causative) version. According to this hypothesis, all verbs that participate in this alternation will be unaccusative (in the inchoative form); however only a subset of verbs classified as unaccusative participate in this alternation.

Finally, there are resultatives. Levin and Rappaport (1995) make the following generalization (the Direct Object Restriction): resultative phrases can only be predicated of the underlyingly immediately post-verbal NP, not of subjects or oblique complements (p. 34). Thus, unergative verbs—which have no post-verbal argument—are predicted to be incompatible with resultative phrases. This is shown in (33a); (33b) is only possible because a so-called "fake reflexive" (Simpson, 1983a) is supplied. Likewise, oblique complements, as in (34b) and (d), are bad with resultatives (cf. their direct object counterparts in (34a) and (c)).

(33)   a.   *Lucy ran breathless[15]
           b.   Lucy ran herself breathless

(34)   a.   John loaded the wagon full with hay
           b.   *John loaded the hay into the wagon full
           c.   John was shot dead
           d.   *John was shot at dead
               (Levin and Rappaport, 1995)

In contrast, unaccusatives are just fine with resultatives, as are passives, as (35)-(36) demonstrate.

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15 The '*' here indicates that the resultative reading is not available; note that there is a grammatical interpretation of this sentence which could be paraphrased as '*Lucy ran while she was breathless*'.

(35) a. The window swung shut/open
     b. The magazine slid onto the floor/off of the table
     c. The egg broke/cracked open

(36) a. The kids were shaken awake by their parents
     b. The table was wiped clean

The contrast between (33) and (35) suggests that there is a meaningful class distinction between unergative and unaccusative verbs, and that this difference can be diagnosed syntactically.

To sum up, there seem to be 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 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.[16] 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: Picture description with intervening trials.*

Priming has been shown for the transitive alternation (passives are produced more frequently after passive primes than after actives) over short and long lags (Bock and Griffin 2000), but previous experiments have not systematically manipulated the type of sentence that intervenes between the prime and target. The reason is in large part due to an

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16 'Deep unaccusativity' diagnostics like causativization and resultatives seem easier to use as tests in English, but strictly speaking, they only diagnose a structural property given a theory of how the lexical semantics structure of a verb gets mapped onto a syntactic representation. I use these tests here under the assumptions that there is a class of unaccusative verbs, and that 'deep' and 'surface' diagnostics will overall pick out the same set of intransitive verbs as unaccusatives.

underlying assumption that structural priming only affects structures that participate in a syntactic alternation; in particular, this means that sentences with a different number of arguments will not even be eligible for priming (cf. Griffin and Weinstein-Tull 2003). For instance, even though unaccusatives and passives share the property that their surface subjects are Themes, unaccusatives would not be expected to interact or interfere with passive priming because they only have one argument.

On another view, unaccusatives should be expected to interact with passive priming, precisely because they share with passives (among other things) the structural property that an internal argument is promoted to subject position, and it is this property that is targeted by priming. Experiment 1 sought to replicate previous findings with an additional manipulation—the item intervening between the prime sentence and the target was one of the following three types: (1) an unaccusative sentence, (2) a copular sentence, or (3) a three-word list. The test case was the unaccusatives: if unaccusatives could interact with structural priming of passives, they might be expected to increase the magnitude of priming after a passive prime. Copulars were intended to serve as a baseline control (i.e. an intervening sentence, but not sharing the structural property that passives and unaccusatives have in common). The word lists served as another baseline, in this case to determine if the magnitude of priming depended on whether the intervening item was a sentence or a non-sentence[17].

2.1.   *Method.*

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[17] Because copular sentences have active morphology, one conceivable outcome was that copulars would prime actives, even though they aren't eventive (the subject of a copular sentence is not an Agent). Word lists were included for this reason as a condition which required lexical items to be processed, but not as part of a sentence (in particular, no tensed verb was processed, since all the words were nouns).

Participants. Subjects for the experiment were undergraduate students from UCLA. 47 native speakers of American English participated in the experiment. They received credit toward fulfilling a requirement in an introductory linguistics course.

Materials. A priming sequence is defined as one sequence of trials consisting of (i) four filler math problems, (ii) one pre-recorded prime sentence, (iii) one pre-recorded interval item (an unaccusative sentence, copular sentence, or word list), and (iv) one target picture. This is represented schematically in Table 1 below.

Trial	Event	Response
1	Filler math problem ('23 + 37 =')	Enter answer on keyboard ('61')
2	Filler math problem	Enter answer on keyboard
3	Filler math problem	Enter answer on keyboard
4	Filler math problem	Enter answer on keyboard
5	Prime sentence ('The cheerleader was accosted by the rival team member')	Repeat Old/New decision (button press)
6	Interval item ({'The senator arrived late'/'The suitcases were heavy'/'journey—insight—symphony'})	Repeat Old/New decision (button press)
7	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 54 black and white drawings, each one depicting a transitive event that could be described by either an active sentence (e.g. *A shark is attacking a surfer*) or its full passive counterpart (e.g. *A surfer is being attacked by a shark*). In 18 of the pictures, the patient role corresponded to a human entity, while the agent was inanimate or nonhuman. In 31 pictures, agent and patient matched in animacy: both were human, both were animate but nonhuman, or both were inanimate; this count includes 7 sentences in which the patient or theme was inanimate, and the agent was a natural force (e.g. *The tornado is destroying the house*, or *The lightning is striking the tower*). The remaining 5 pictures had an animate

(human or nonhuman) agent with an inanimate patient/theme[18]. To control for potential left-right orientation effects in picture descriptions (Flores D'Arcais 1975), 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. Figure 1 shows one mirror-image pair used in Experiments 1 and 2.

Figure 1. Mirror-image target picture pair. *(Possible descriptions: 'The shark is attacking the swimmer' / 'The swimmer is being attacked by the shark'.)*

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

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18 Sentences of this type—where the agent is higher on the animacy scale than the patient/theme—were largely avoided based on Bock and Loebell (1990), who found a robust humanness effect: people strongly prefer to make a human agent the subject of the sentence. This effect apparently overwhelms any effect of prime type, and further, only matters in the target picture; that is, no such humanness effect was found for prime sentences, such that a human argument appears more often as the subject of the picture description sentence when it follows a prime sentence with a human subject. (More on this in the Discussion of Experiment 1.)

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%).

There were 27 prime pairs, each of which included an active sentence (e.g. *The secretary embezzled the money*) and its passive counterpart (e.g. *The money was embezzled by the secretary*). For 47 of the 54 prime sentences, the arguments were definite (as in the above example); the remaining 7 prime sentences contained two indefinites (e.g. *An audience member recommended a book*/*A book was recommended by an audience member*). Arguments matched in definiteness for all prime items[19].

In addition to the prime sentences, there were interval items which involved one of three stimulus types. There was a set of 9 sentences with unaccusative verbs[20] (e.g. *The senator arrived late*), a set of 9 copular sentences with either adjectival predicates (e.g. *The suitcases were heavy*) or locative prepositional phrases (e.g. *The supplies are in the closet*), and finally a set of 9 word lists. Each word list consisted of three words (all nouns), drawn from a list of words matched for adjusted frequencies (Francis and Kučera 1982). In addition, one active transitive sentence, one copular sentence, two double object sentences, one word list (not overlapping with any word list appearing in the experiment), and two pictures (both of which reliably elicited unergative intransitive descriptions) were used in practice trials.

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19 Definite descriptions were predominantly used in order to avoid introducing the possible wide-scope behavior of indefinites as an (unwanted) extra factor.

20 Unaccusativity diagnostics used include the availability of there-insertion and compatibility with resultatives, among others (Levin & Rappaport, 1995; see section 1.3.2 above).

All of the sentences and word lists were digitally recorded at a sampling rate of 44kHz by a female native speaker of North American English[21].

In order to make the cover memory task realistic (see *Procedure* for Experiment 1), each of the interval items was presented twice; consequently, 9 of 18 trials in a particular interval condition were first occurrences of an item, and the remaining 9 trials were second occurrences. None of the prime sentences or target pictures were repeated, but some of the pictures were similar enough to each other to give the appearance that all item types in the experiment were repeating unpredictably.

Math problems were used as filler items. Sequences of priming trials (see Table 1) were separated by four filler items, all of which required subjects to add two two-digit numbers in their head and type their answer on the keyboard. To increase the difficulty of the task, all the problems involved carrying, and were presented in a horizontal line on the computer screen (e.g. *47 + 39 =*). There were a total of 378 items in the experiment (54 primes, 54 targets, 18 items in each of three interval conditions, and 216 fillers between priming sequences, divided into 54 blocks of 4 fillers each), plus 8 practice items.

Design. The design crosses Prime Type (Active or Passive) and Interval Type (Unaccusative, Copular, or Word list recall). Each subject saw nine prime sequences from each of the 6 cells of the experiment (see Table 2).

Two lists were created such that an item in one list was the mirror image of the corresponding item in the other list. Half of the target items seen by any subject were drawn from one list, and half from the other; the lists were counterbalanced such that a subject saw only one of the two versions of any picture, and which items were drawn from which list was random.

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21 See the Appendix for a complete list of stimuli used in Experiments 1 and 2.

		Interval type		
		Unaccusative	*Copular*	*Word list*
Prime type	*Active*	P: The manager assessed the situation. I: The senator arrived late.	P: The manager assessed the situation. I: The suitcases were heavy.	P: The manager assessed the situation. I: opponent – courage – fault
	Passive	P: The situation was assessed by the manager. I: The senator arrived late.	P: The situation was assessed by the manager. I: The suitcases were heavy.	P: The situation was assessed by the manager. I: opponent – courage – fault

Table 2. Experiment 1: Prime Type x Interval Type. *(P = prime; I = interval item.)*

Order of presentation of prime sentences, interval sentences/word lists, and target pictures was randomized for each run of the experiment, so each subject saw a randomly generated prime-interval-target combination for each trial. These items were arranged and presented as mixed lists of pictures and sentences. Active and passive prime types were counterbalanced such that only one sentence from each of the 54 prime sentence pairs appeared on each list.

Procedure. On all prime sentences and interval items, subjects listened to the sentence or word list, 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 math problem appeared on the screen, and subjects had to calculate the answer and enter it using the keyboard.

All events in the experiment were controlled by a Macintosh computer running PsyScope software (J.D. Cohen, MacWhinney, Flatt, & Provost 1993). Subjects proceeded through the items in the experiment using the PsyScope button box: the green and red buttons were used to indicate 'yes' and 'no' responses and proceed to the next trial, and the

yellow button was used to go to the next trial after math items. At the beginning of each prime and interval trial, a sentence or word list was presented auditorily; at the offset of the auditory stimulus, the prompt "Repeat" appeared on the screen (and remained there until the end of the trial). After repeating the sentence or word list into the microphone, the subject pressed the red or green button to continue on to the next trial.

On picture description items, a target picture was displayed on the screen along with the prompt "Describe". The image remained on the screen while the subject spoke into the microphone. Again, the subject indicated whether or not they had seen the picture previously by pressing the red or green button.

Sound files were played through headphones worn by subjects during the experiment. Subjects' responses were recorded on a digital recorder for later coding. (Answers to the math problems used as fillers were also recorded in a text file for the purpose of filtering out subjects who weren't actually calculating the sums between prime sequences.)

Subjects were run individually. They were told that the experiment was about memory of pictures and sentences, and how memory tasks might affect simultaneous performance on math problems requiring a possibly different type of mental computation. Following Bock (1986b), subjects were instructed to repeat the sentence/word list they heard (on prime and interval trials), and describe what was going on in the picture (picture description trials), to help with the memory task. Three examples of a picture description trial were embedded in the instructions; the sample answers (pre-recorded by a native American English speaker different from the one who recorded the experimental stimuli) included one unergative sentence and two active transitive sentences. The instructions were followed by five practice items (two pictures, one sentence, one word list, and one math problem). The experimenter was in an adjoining room (not visible to the subject)

during the experimental session. The length of an average session was 45-50 minutes, including a short break between the two experimental blocks (which contained trial sequences of the same type and structure).

2.2.   *Results.*

Coding responses. Both *be*-passives (*The swimmer is being attacked by the shark*) and g*et*-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.

Whenever some predicate other than the intended one was used to describe a target picture, the response was coded as an active or passive response only if it had a well-formed passive or active counterpart. For instance, *The truck is hauling the car* was scored as an active response (intended: *The truck is towing the car*), because the passive counterpart *The car is being hauled by the truck* is well-formed; a response such as *The robber is getting away from the cops* (intended: *The cops are chasing the robber*), however, was counted as an 'other' response, since the passive counterpart—*The cops are being gotten away from by the robber*—is unavailable. The logic of excluding such responses is that, given those lexical choices for the main verb, there was no other surface form for the sentences to take; if we assume that active and passive forms compete with each other in sentence production, counting responses for which no well-formed alternative exists would be giving either the number of active or passive responses an unfair advantage. Following this criterion for accepting responses, ditransitive sentences were also coded as active or passive as long as their active/passive counterparts were well-formed. For example, *The woman put the t-shirt on the baby* would be coded as 'active',

since the passive sentence *The t-shirt was put on the baby by the woman* is good; likewise, a double object sentence like *The girl gave the boy some cereal* would count as 'active' since the passive sentence *Some cereal was given to the boy by the girl* is available. (This departs from the coding criteria used by Bock and colleagues, who only consider transitive sentences as eligible for structural priming in the first place.)

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). In particular, this meant that responses involving Experiencer-Theme verbs were counted as 'other' responses; verbs of this class are typically Psych verbs (*The snake scared the girl; The girl was scared by the snake*) or Perception verbs (*The girl saw the snake; The snake was seen by the girl*)[22]. Only a handful of such cases were encountered in the picture descriptions.

Sentences with raising verbs (e.g. *The wave is about to destroy the sandcastle*; intended: *The wave is destroying the sandcastle*) were also for the most part counted as active/passive responses, provided the active/passive counterpart was well-formed (*The sandcastle is about to be destroyed by the wave*). Control verbs differ from raising verbs in this respect: because a control verb assigns a theta role to its matrix clause argument (as in *The prisoner is trying to escape from the jail*), passivizing the internal argument of the embedded verb yields a sentence with a different meaning (*%The jail is trying to be escaped by the prisoner*). For this reason, control sentences were not counted as scorable active/passive responses.

With the exception of raising infinitivals, all responses were coded as active or passive sentences only if the relevant verb was the main verb of the sentence (so a response like *The mailman is scared of the dog that is attacking him* was not counted as an active response). Disfluent starts were not considered—in other words, the main verb of the first

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22 See Belletti and Rizzi (1988) and Pesetsky (1995), among others, for discussion of the syntax of Experiencer verbs.

full (tensed) sentence counted for purposes of scoring responses (e.g. *cover* in *The car...the mountain is avalanch-.... The car is being covered by the snow on a mountain*). Of the 1624 responses, 49.5% were codable by these criteria, with 246 passive and 557 active responses.

Remaining responses were coded as 'other' and excluded from the analysis. Excluded items included responses from trials where the prime sentence was not reproduced successfully, and disfluent utterances where no clear main verb was used. 41.9% of responses were omitted overall.

Analysis. The dependent measure was the proportion of Passive responses in each condition. All subjects and items were given a score for each cell of the experiment; so for example, a subject's score was the number of passive sentences produced as a proportion of that subject's codable responses for a particular condition. Mean percentages of Passive responses for each condition are given in Table 3.

Prime type	Interval type			
	Unaccusative	*Copular*	*Word list*	*Mean*
Active	26.6	23.5	31.5	27.2
Passive	31.5	33.7	31.8	32.4
Mean	29.1	28.6	31.7	

Table 3. Summary of Experiment 1 results. *Each cell contains the mean percentage of Passive responses out of all codable responses for that cell.*

Analysis of variance was performed treating subjects as random effects. All analyses were additionally performed on arcsine-transformed data (Smith, 1976; Winer, 1991); all effects reported obtained for both transformed and raw data, and only the latter are reported. Effects with $p \leq .05$ are reported as significant throughout.

A two-way ANOVA revealed a main effect only of Prime Type (by subjects; F1

(1,28) = 4.03, p<0.05), but no effect of Interval Type (F<1), and no interaction between Prime Type and Interval Type (F<1).
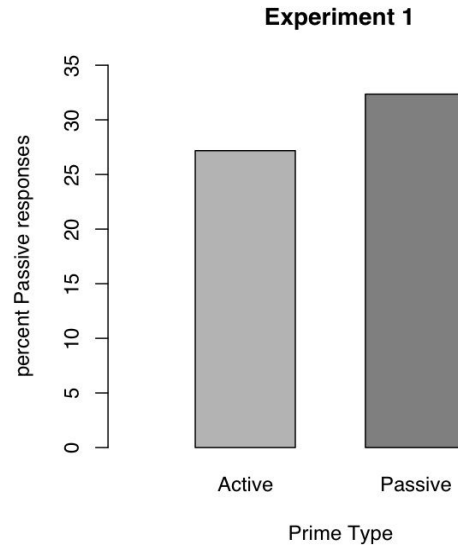
Experiment 1

Figure 2. Percentage Passive responses in Experiment 1,
by Prime Type (collapsed over Interval Type).

The proportion of passives after passive primes was larger than the proportion of passives after active primes, as shown in Figure 2, which collapses over levels of the Interval Type factor.

2.3. Discussion.

The main effect of Prime Type replicates results of previous priming studies that found structural priming with the transitive alternation. However, there was no interaction with Interval Type—and in retrospect, probably for very plausible reasons. The first is that the Copular sentence conditions might not have been serving their intended purpose. They were intended to contrast with the Unaccusative conditions by not having an internal argument that is promoted to subject position, but a major account of copular sentences is that they do have this property—in effect, they are unaccusative constructions (Stowell

1978, among others)[23].

Second, while unaccusatives share some properties with passives, there are other things that make them similar to actives, and different from passives. Most noticeably, unaccusative sentences have active morphology on the main verb (in fact, a characteristic property of unaccusatives is that they cannot appear in passive form). As an unintended consequence of this, all the unaccusative and active sentences used in the experiment appeared as simple verbs (with active morphology), while all the passive sentences were compound forms (all with auxiliary verb 'be', and participial morphology on the main verb). Because there very well may be independent priming associated with lexical items or verbal morphology, any effect due to 'underlying' structural properties of unaccusatives may have been washed out.

There was another serious problem with the experimental stimuli in light of previous findings of animacy (sometimes: humanness) effects on word order[24]. To begin with, it's non-controversial that word order tendencies and preferences can be influenced by various non-structural factors. For instance, given information (information known to both speaker and hearer; backgrounded information) tends to occur earlier in a sentence relative to new information (foregrounded or focused information) (Haviland and Clark 1974); relatedly, Tomlin (1983) suggests that given/topical Themes tend to be produced in passive sentences. Other properties such as imageability and concreteness (Bock and Warren 1985), and prototypicality (Kelly, Bock and Keil 1986) make an argument more likely to surface as subjects of sentences, compared to arguments that are not imageable, concrete, or prototypical.

Exactly this kind of word order preference has been reported repeatedly for

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23 Such an account takes the unique (internal) argument of the copula, in a sentence like *The door is open*, to be the adjective phrase *[AP the door [A' open]]*. The NP *the door* extracts out of the AP and surfaces as the subject of the sentence.

24 See F. Ferreira (1994) for an overview of effects of this type in the context of passives.

animacy. MacWhinney (1977), and Bates and MacWhinney (1982) observed that animate arguments are more likely than inanimate ones to appear as surface subjects. Similarly, McDonald, Bock and Kelly (1993) find that animate nouns appear more frequently as subjects of transitive sentences (than inanimate ones), but not as initial arguments in conjoined nominals within sentences, and take this to mean that animacy is relevant for grammatical function assignment (or possibly thematic role assignment), but not linear ordering of arguments in general.

Particularly relevant for Experiment 1 are two sets of findings having to do with animacy in production (Bock 1986b; Bock, Loebell and Morey 1992). In Bock's 1986b study, a humanness effect is found such that, in target pictures containing a human and a nonhuman, the human argument tends to be mapped onto the subject position. No such (humanness or animacy) effect is found for prime sentences (such that if there is a human/animate argument in the prime sentence, the human/animate argument tends to surface as the subject in the target description)[25]. With this result in mind, the target pictures but not the prime sentences in Experiment 1 were constructed such that the majority of pictures contained either (i) matching-animacy argument roles, or (ii) a human Theme with a nonhuman (animate or inanimate) Agent (see Materials section above). Because it was thought that animacy in the prime sentences would not interfere with structural priming, primes were constructed focusing primarily on how comparable active and passive versions were in sounding 'natural'—the resulting list of prime items happened to end up with many sentences containing animate Agents and inanimate Themes.

There was a second relevant finding, however (Bock, Loebell and Morey 1992): a prime sentence with an inanimate subject is followed more often by a target description

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25 Such an effect could potentially be one of (at least) two things: (1) a human/animate argument anywhere in the prime sentence has an effect on where the human/animate argument surfaces in the target description—say, in subject position; (2) if there is a human/animate argument in the prime sentence, there is a tendency for a human/animate argument in the target description to surface in the same position as in the prime sentence.

with an inanimate subject (than a prime with an animate subject is). If this result is to be interpreted as animacy features on arguments in specific structural positions in the prime being matched by animacy features on arguments in the same structural positions in the target, the most common trial types in Experiment 1 are predicted to be as follows: (1) *The manager arranged the meeting* (Active prime, animate subject)   *The skateboarder was hit by the taxi* (Passive response, human subject); (2) *The meeting was arranged by the manager* (Passive prime, inanimate subject)   *The taxi hit the skateboarder* (Active response, nonhuman subject). Although the overall effect of Prime Type came out significant in Experiment 1, it seems probable that animacy mismatches in the prime sentences as well as the interval items (animacy matching not controlled across items or across levels of Interval Type) introduced a lot of unwanted noise into the data.

3. *Experiment 2: Adjacent priming of Unaccusatives and Passives.*

Experiment 2 rests on the same basic assumptions as Experiment 1—namely, that if unaccusatives and passives share some structural property, it should be possible to target that property with structural priming. The problems discussed above for Experiment 1 were addressed in a couple different ways. First, the design of the experiment was simplified by eliminating the Interval Type factor, and instead including unaccusatives as one of three Prime types. In order to minimize differences in lexical overlap and verbal morphology (potential sources of priming), all prime sentences appeared in past progressive form—so *be* always appeared in the past tense, and there was always a verb in progressive form (the passive auxiliary for passive primes, the main verb for active and unaccusative primes). Finally, taking into account Bock et al's (1992) animacy effect, all prime sentences contained only animate arguments, and only target pictures depicting animacy-matched argument roles were included in the experiment.

3.1   Method.

Participants.   As in Experiment 1, subjects were undergraduate students from UCLA.   54 native speakers of American English (none of whom had participated in Experiment 1) participated in the experiment; of these, 7 participants who grew up in bilingual households were excluded, leaving 47 monolingual English speakers.   They received either extra credit in an introductory linguistics course, or $8 compensation 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 4. Sample priming sequence for Experiment 2.

The materials for Experiment 2 were adapted from and largely overlapped with the items used in 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.   In contrast to Experiment 1, all of the experimental pictures depicted participants matching in animacy. This excluded pictures with one inanimate agent or patient (e.g. *The cab is hitting the skateboarder*), and included pictures with two inanimate entities (e.g. *The tank*

is crushing the bicycle) or two animate entities[26] (e.g. *The tiger is chasing the man*, or *The dog is pulling the boy*).

As all but three images in Experiment 2 had been used in Experiment 1, norming data was not collected for the pictures used in Experiment 2. However, some of the items were excluded from Experiment 2 based on descriptions elicited in the first experiment (i.e. the majority of descriptions for these items were coded as 'Other', either because an alternate sentence form was frequently used, or because many subjects had difficulty producing a coherent, one-sentence description of the image). An informal survey of a few native English speaking students suggested that the three pictures new to the current experiment would be unproblematic for eliciting transitive sentences[27].

There were 36 prime sentences; these 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*). To minimize any potential effects due to the presence of the verb 'be' or verbal morphology, all prime items were in past progressive form, as in the examples given above. All prime sentences contained only definite arguments.

In order to keep the speaker that subjects heard constant from trial to trial, all of the prime sentences were rerecorded. Sentences were digitally recorded at a sampling rate of 44kHz by a male native speaker of North American English.

Filler items were different from those in Experiment 1; some subjects in the

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26 Note that this includes pictures involving participants not matching in humanness (as in the examples given).

27 The new items depicted: (1) a boy kissing a girl on the head, (2) a girl hugging a boy, and (3) a barber shaving a man).

previous experiment found it difficult to keep track of the different tasks required for experimental trials (repeat/describe, old/new decision via button press) and filler trials (math problems answered using the keyboard), so the fillers in Experiment 2 were adjusted such that the same instructions could be given for all trials in the experiment. In half of the fillers, a set of three 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[28]. 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.

Each of the filler items occurred twice per run of the experiment; in addition, some of the word and number sets included words/numbers that appeared in other filler items. None of the prime sentences or target pictures were repeated. The practice block included one active transitive sentence, one copular sentence, two double object sentences, one word set, one number set, and two pictures (both of which reliably elicited unergative intransitive descriptions).

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 5. 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), as in Experiment 1.

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28 The word sets were adapted from the words used in Experiment 1 for the word list recall conditions (i.e matched for adjusted frequencies).

Prime type		
Active	*Passive*	*Unaccusative*
'The detective was interrogating the inmate'	*'The inmate was being interrogated by the detective'*	*'The representative was arriving late'*

Table 5. Experiment 2: Prime Type.

Although care was taken in preparing the items for Experiment 1 to ensure that any two adjacent items would not be conceptually or thematically related, or end up overlapping in lexical elements, the fact that prime-target pairings were generated randomly for each run limited how closely this aspect of the stimuli could be controlled. To minimize this potential source of noise in Experiment 2, four stimulus lists were created. All lists contained 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. The procedure for Experiment 2 was identical to that of Experiment 1, with the exception of the filler trials (described above). The length of an average session was 20-25 minutes, including a short break between the two experimental blocks.

3.2.   Results.

Coding responses. Responses were coded using the same criteria as in Experiment 1. 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. Means percentages of Passive responses by condition and pairwise comparisons of condition means are given in Table 6.

Prime type	*Active*	*Passive*	*Unaccusative*
Mean percentage Passive responses	8.5	15.3	14
Pairwise comparisons	*Passive—Active*	*Unaccusative—Active*	*Passive—Unaccusative*
Difference in means, Tukey HSD (95% confidence interval)	6.83 (1.68,11.98)	5.53 (0.38,10.69)	1.30 (-3.86,6.45)

Table 6. Summary of Experiment 2 results.

Analysis of variance was performed separately treating subjects and items as random effects[29]. One-way ANOVA showed that condition means were significantly different from each other; this was significant by subjects only ($F_1(2,86) = 5.64$, p<0.01; F_2<1).

As shown in Figure 3, the proportions of Passives produced after both Passive

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29 All 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.

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)); see Figure 4.
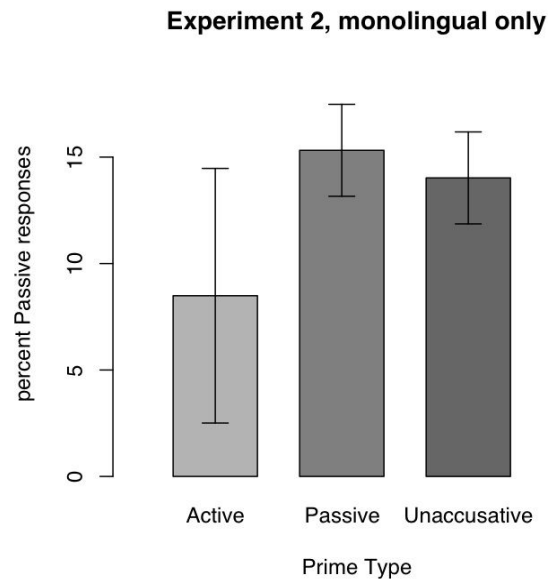
Experiment 2, monolingual only

Figure 3. Percentage Passives in Experiment 2, 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 (Holm 1979) 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).
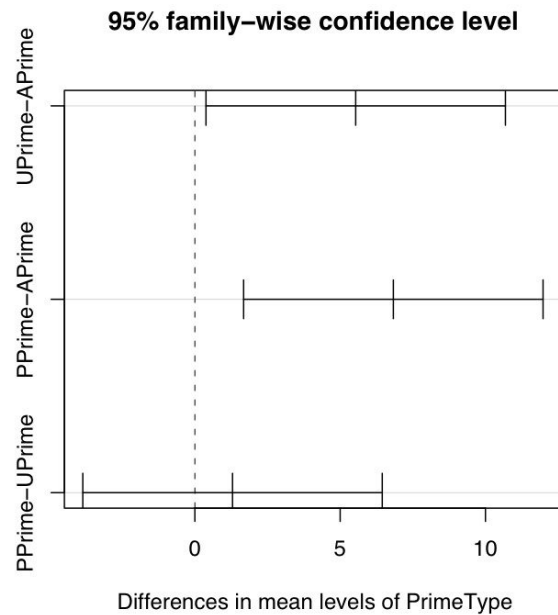
95% family-wise confidence level

UPrime-APrime

PPrime-APrime

PPrime-UPrime

Differences in mean levels of PrimeType

Figure 4. Tukey HSD Pairwise comparisons of condition means
(differences with lower bound ≥ 0 are significant).

3.3. Discussion.

As in Experiment 1, Passive primes were followed by more Passive descriptions than Active primes—this again replicates findings in the experimental literature. In addition, Unaccusatives were successful at priming Passive responses: higher proportions of Passive sentences were produced following Unaccusative sentences than following Actives. There was no significant difference in the magnitude of priming for Passive and Unaccusative primes.

Because several changes were made in the design and materials of Experiment 2 based on problems encountered in Experiment 1, it won't be possible to determine the source of the difference between the two sets of results. In Experiment 1, a combination of animacy-related factors conspired to push the distribution of Passive responses in the direction opposite to what was predicted by structural priming; while this source of noise in

the data was probably eliminated by making sure that no stimuli contained animacy-scale mismatches, the fact that there was a Prime Type effect in Experiment 1 suggests that animacy asymmetries weren't the only reason no effect of Unaccusatives was obtained. If copular sentences are indeed correctly analyzed as having the syntax of unaccusatives (e.g. Stowell 1978, 1991; Moro 1991; Hoekstra 1988; Hoekstra and Mulder 1990), the Unaccusative and Copular Interval type conditions in Experiment 1 would be predicted not to differ; however even if this is the case, something else needs to be said about why these two conditions did not differ from the Word list condition. Another adjustment made to Experiment 2 stimuli—matching (as closely as possible) the degree of morphological overlap across prime types—may have reduced variability of response types (e.g. tense/aspect in the response sentence; whether a simple or compound verb form was used) across conditions.

In addition to the changes just mentioned, Experiment 2 was substantially easier for subjects as a whole: the filler items involved an old/new recognition task instead of an arithmetic calculation task, the instructions were revised to allow participants to remember a single set of instructions as opposed to different sets of instructions for different trial types, and experimental sessions were on average half as long as a typical Experiment 1 session. Also possibly relevant is that Experiment 1 was looking for an interference effect on a priming effect, while Experiment 2 tested for priming directly; there don't seem to be any agreed-upon generalizations from the literature about how intervening items affect priming when prime and target are non-adjacent.

4.   *General discussion.*

The status of underlying structure. On the face of it, the results of Experiment 2 are at odds with Bock, Loebell and Morey (1992), who argue based on their findings for a

"direct mapping" view of syntactic structure—that is, one in which something like passive is represented in the lexicon as the output of a lexical rule, and mapped directly onto a structural form. Based on the result that Unaccusatives primed Passives in Experiment 2, my inclination is to argue for the opposite position—that there is a level of underlying structural representation at which unaccusatives and passives are structurally similar, and that these non-surface representation are actually implicated in sentence production (since they are detectable in a production task using structural priming). This said, it's unclear that the Bock et al study really constitutes evidence for the non-existence of such underlying representations; on the other hand, it's also unclear whether the effect reported here is truly a case of syntactic structural priming.

The broad question Bock, Loebell and Morey (1992) pose is how conceptual features that subjects tend to share (e.g. animacy) are related to structural properties of arguments in subject position—essentially, this is the problem of how thematic or conceptual roles at the message level are mapped onto grammatical functions and surface structural positions. Two theoretical positions are distinguished: according to one (what they term "mediated mapping"), thematic information is encoded at an underlying level of syntactic structure, and syntactic operations create the final surface constituent order; according to the other view ("direct mapping"), "syntactic functions are individuated with respect to verb forms" (p. 151), allowing for a direct mapping of thematic roles to surface structure. While the former posits different levels of syntactic representation that are related by movement operations (i.e. deriving possibly different surface structures from a common "deep structure" representation), the latter relies on lexical rules, which encode systematic relations between subcategorization properties of related verb forms (e.g. active/passive). Further, the authors make the point that verb forms derived by lexical rules may be stored, instead of each instance being generated repeatedly for each use of a verb

form—in other words, the root form of a verb is not thought to be accessed when, for instance, a passive sentence is produced.

To summarize Bock et al's characterization of the two models: in the mediated mapping model, the message level is followed by selection of an appropriate verb, which will come with item-specific lexical information, e.g. selection information; it's assumed that linking information is also specified, but an independent principle along the lines of UTAH or some version thereof would do just as well—in either case, specific thematic roles are linked to specific "deep structure" positions. Say we choose the verb *chase* as an example. The underlying structure is built by mapping *boy* (the agent) onto the specifier position of the verb *chase*, and *squirrel* to the complement position, giving something like: [VP boy [V' chase squirrel]]. Some syntactic operations happen (according to some, this will depend on what functional elements have been selected/enter into the derivation), and the surface structure that results may match the underlying structure in the linear ordering of arguments (*The boy chased the squirrel*), or not (*The squirrel was chased by the boy*). In the direct mapping model, there is no level of underlying structure that is shared by surface strings that share lexical content: lexical rules generate alternative verb forms, each with their own selectional properties (e.g. chase <subject-DPagent, direct_object-DPpatient> → be_chased <subject-DPpatient, oblique_object-PPagent>), which are stored as separate lexical entries. One such a form is selected (e.g. *be chased*), the arguments are assigned grammatical functions based on the form chosen (*boy* is assigned 'oblique object', *squirrel* is assigned 'subject'). These arguments, along with the verb form, are then mapped onto a syntactic representation like *The squirrel was chased by the boy*.

The experiment reported by Bock et al—which uses the picture description paradigm—focuses on the conceptual feature '(in)animate', and tests predictions from the mediated and direct mapping hypotheses about which conditions will show an effect of

animacy priming. All target pictures depicted events with an animate patient and an inanimate agent/causer: e.g., an alarm clock waking a boy. The two mapping hypotheses differ in what might be subject to priming: since mediated mapping posits a level of underlying structure in which surface objects of actives and surface subjects of passives are mapped onto the same position (linked to a particular theta role), a conceptual feature shared by the object of an active and the subject of a passive might be able to prime each other. That is, a prime sentence like *Five people were carried by the boat* (underlying direct object/patient role is animate) might prime the target description *The alarm clock woke the boy* (surface direct object/patient role is animate), whereas the prime *The boat was carried by five people* (underlying direct object/patient role is inanimate) might not be expected to prime *The alarm clock woke the boy* (surface direct object/patient role is animate; this condition is designed not to have a primable surface realization, under the assumption that there is no verb with the meaning of *wake* for which the patient surfaces in subject position in the active form). The direct mapping model predicts that *The boat was carried by five people* (surface subject is inanimate) will prime *The alarm clock woke the boy* (surface subject is inanimate), whereas *Five people were carried by the boat* (surface subject is animate) will not.

Bock et al find that a prime sentence with an animate subject is more often followed by a target description with an animate subject (not: a prime sentence with an animate patient role primes target descriptions with an animate patient role), and take this as evidence in favor of the direct mapping view over mediated mapping. While this result is compatible with the direct mapping hypothesis, it clearly doesn't rule out the existence of a mediating level of structural representation that is shared by e.g. active and passive alternates of a sentence. There may very well be surface preferences (say, a preference for the initial argument of a sentence to match previous initial arguments in animacy/other features; even: a preference for maintaining general information structure like topichood

across utterances) which are not built into the machinery that generates sentence structures. These 'surfacy' preferences may overwhelm or render less detectable any potential effect of underlying structure, or it might simply be that properties of underlying representations are not detectable with priming methods of this type. The latter point is shown not to be the case, here.

      <u>Deconfounding syntax and thematic structure.</u> Experiment 2 has shown only that unaccusatives and passives have in common that they are both able to prime passives. The big question now is whether the source of this effect was truly syntactic, or whether it can be reduced to priming of thematic structure. Table 7 represents experiments (existing and hypothetical) where thematic structure and syntactic structure are confounded or pulled apart: '+' and '—' indicate whether prime and target overlap on that factor (syntactic or thematic structure); the row marked '?' are cases involving unaccusatives.

      Chang, Bock & Goldberg (2003) address the question of whether there is thematic priming independent of syntactic structure: in order to pull the two apart, they 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). The prediction is as follows: if there is an effect of thematic structure independent of syntactic structure, theme>location primes should be followed by more theme>location target utterances than location>theme ones. Potter & Lombardi's RSVP sentence recall paradigm is used to test this prediction, which is born out: location>theme sentences were more likely to follow location>theme primes than theme>location primes, and theme>location sentences were more likely to follow theme>location primes than location>theme primes. This contrast is shown in the top two cells of Table 7.

		Thematic structure	
		+	**—**
Syntactic structure	**+**	Bock 1986b: The girl gave [a present][to the boy] → The woman showed [a picture][to the child] Chang et al 2003: spray [the wax][onto the car] → spread [the butter][onto the bread]	Bock & Loebell 1990: The widow drove [the Mercedes][to the church] → The widow gave [the Mercedes][to the church] Chang et al 2003: spray [the wax][onto the car] → spread [the bread][with butter]
	?	Experiment 2: The guests arrived ('the guests' = theme) → The arsonist was arrested by the police ('the arsonist' = theme)	*The guests arrived ('the guests' = theme) → Bill was angered by Mary ('Bill' = experiencer; 'Mary' cause)*
	—	The letter reached the office ('the letter' = theme) → The package was mailed to Philadelphia ('package' = theme) Mary received the award ('Mary' = goal) → The secretary was given a present ('the secretary' = goal)	The children ran ('the children' = agent) → Mary admires Bill ('Mary' = experiencer; 'Bill' = theme) Mary gave Bill a book ('Mary' = agent; 'Bill' = goal) → The children angered the babysitter ('the children' = cause; 'the babysitter' = experiencer')

Table 7. Summary of comparison types from previous/current experiments.

Because thematic priming has been shown to exist independently, the possibility that Unaccusative—Passive priming is due to thematic overlap cannot be excluded. In fact, recent work by Melinger (2006) reports the same effect (priming from Unaccusatives to Passives; also from Unergatives to Actives) but reaches precisely this alternative conclusion: she argues that because movement does not feature in existing models of sentence production, the purported syntactic similarity of Unaccusatives and Passives can simply be excluded as a possible source of priming. In contrast, I want to address the question of whether the theoretically-motivated syntactic properties of Unaccusatives and Passives ought to be represented in sentence production, by trying to isolate effects of these structural properties in processing.

What's really needed, then, is a case where syntactic priming can be tested for—in

cases where the syntactic parallel between two sentence types is in question, like passives and unaccusatives—but without the confound of primes and targets also matching in theta structure. An obvious test case (italicized in Table 7) is the following: do Unaccusative sentences (Theme subject, e.g. *The guests arrived*) prime the Passive form of a Causer-Experiencer verb (Experiencer subject, e.g. *The students were angered by the TA*); this case would test whether there is truly a syntactic priming relationship between Unaccusative and Passives in the absence of overlapping thematic structure. Experiencer verbs may be difficult to use as target sentences in an experiment like Experiment 2, simply because the picture description paradigm used here requires the targets to be depictable in a picture, such that they reliably elicit descriptions of the intended type. A way around the problem of drawing psych verbs is to use them as prime sentences instead of targets; such an experiment would cross Verb Type (Agent-Theme verb, Causer-Experiencer verb) with Structure (Active, Passive), as illustrated in Table 8. As in Experiments 1 and 2, the dependent measure would be the proportion of Passive responses out of all codable picture descriptions for each cell of the experiment.

		Verb type	
		Agent-Theme verb	**Causer-Experiencer verb**
	Active	*The girl kicked the clown*	*The children annoyed the babysitter*
Structure	**Passive**	*The clown was kicked by the girl*	*The babysitter was annoyed by the children*

Table 8. Example prime sentences; hypothetical experiment deconfounding thematic and syntactic structure[30].

The crucial comparison will be whether the Passive Causer-Experiencer primes are followed by more passive picture descriptions to the same extent that the Passive Agent-

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30 For the sake of convenience, 'Agent-Theme' and 'Causer-Experiencer' are used to refer to (typically) action verbs which take an Agent subject and a Theme direct object in the active form, and psych verbs which take a Causer subject and an Experiencer direct object in the active form, respectively.

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 (Giorgi 1984; Belletti and Rizzi 1988; Pesetsky 1987, 1995; Marantz 1997; Pylkkanen 1998; Arad 1998; 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[31].

Such an experiment would not, however, allow us to ask the specific question that arose in Experiment 2—whether the priming effect from Unaccusative primes to Passive targets couldn't be due to thematic priming. To address that question, you would have to test whether Unaccusatives prime Passive forms of Causer-Experiencer verbs, as much as Passive forms of Agent-Theme verbs do; this re-introduces the problem of eliciting psych verb responses in the picture description paradigm. Using RSVP (Potter and Lombardi 1990, 1998; Lombardi and Potter 1992; Konopka and Bock 2005) instead of picture description would avoid this problem; table 9 shows a possible design for an RSVP

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31 Another potential problem with psych verbs: Baker (1997) suggests that the Experiencer role in *fear*-type psych verbs can be collapsed with Patient/Theme (i.e. they are undergoers of a change of mental state), while Experiencers in annoy-type psych verbs can be collapsed with Agent/Causer (they create/cause certain mental states). If this move toward grouping the standard theta roles into a coarser-grained thematic hierarchy (Dowty's (1990) proto-roles and Pesetsky's (1995) macroroles move in this direction) is on the right track, priming between passive "Causer-Experiencer" verbs and passive Agent-Theme verbs might not be deconfouding thematic roles and syntactic structure after all.

experiment, crossing Prime Type and Target Type.

		Target Verb Type			
		Agent-Theme		Causer-Experiencer	
	Target Structure	Active	Passive	Active	Passive
Prime Structure	Active	*P: The girl kicked the clown* *T: The babysitter fed the children*	*P: The girl kicked the clown* *T: The children were fed by the babysitter*	*P: The girl kicked the clown* *T: The children annoyed the neighbors*	*P: The girl kicked the clown* *T: The neighbors were annoyed by the children*
	Passive	*P: The clown was kicked by the girl* *T: The babysitter fed the children*	*P: The clown was kicked by the girl* *T: The children were fed by the babysitter*	*P: The clown was kicked by the girl* *T: The children annoyed the neighbors*	*P: The clown was kicked by the girl* *T: The neighbors were annoyed by the children*
	Unaccusative	*P: The senator arrived* *T: The babysitter fed the children*	*P: The senator arrived* *T: The children were fed by the babysitter*	*P: The senator arrived* *T: The children annoyed the neighbors*	*P: The senator arrived* *T: The neighbors were annoyed by the children*

Table 9. Hypothetical design for an RSVP experiment. *(P = prime, T = target.)*

Prime sentences alternate with target sentences; the dependent measure is still be the proportion of Passive responses for each cell of the experiment. In the context of an RSVP experiment, the question will be how often target sentences given in Active form are mis-recalled as Passives. If this happens more often when the prime sentence (i.e. the sentence in the immediately preceding trial) is a Passive or an Unaccusative than when the prime is an Active, this will amount to a replication of the structural priming effect reported in Experiment 2, but using RSVP. If the same pattern of priming obtains for conditions where the target sentences are Causer-Experiencer verbs as with Agent-Theme verb

conditions, the priming will be attributable to syntactic structure (in the absence of thematic overlap).

A note on incrementality. There's a big question that remains unaddressed here, and that is how arguments for non-surface-true syntactic representations (e.g. underlying structures that differ from corresponding surface structures in argument order) are to be reconciled with evidence that sentence processing is highly incremental. How can production be incremental and also involve leftward movement? The speaker would have to plan out a sentence to at least the post-verbal argument position before even encoding the subject NP argument. Having movement operations in the production system is also at odds with accessibility effects on passive/active production: Bock (1986a) shows that semantic priming of a constituent makes speakers tend to produce that constituent earlier in a subsequent utterance, yielding either actives or passives. If, however, passives assign arguments to identical/equivalent structural positions as actives, and surface order is derived via movement, the source of the earlier-mention preference in Bock's study doesn't seem to be explained.

No solution is proposed here, but it might be that the representations accessed by speakers and comprehenders during sentence processing are not as fully decomposed into what many theoreticians would argue are their atomic parts. If templatic representations of this type come with frequency information based on language experience and use, psycholinguists will have a way to explain 'surfacy' effects due to typicality, plausibility, thematic-fit, etc. Frazier and Clifton (1996) suggest something akin to this: in particular, lexical entries for verbs are said to include mini tree structures representing possible subcategorization frames, and that people keep track of how frequently they encounter particular syntactic configurations. What remains to be explained, under such an account, is how these non-atomic templatic representations inherit properties of the lexical roots they are derived from; for instance, how much of the syntax of unaccusatives is accessed

when an unaccusative verb is produced or comprehended?

Appendix: Experiments 1 & 2 stimuli.

1.   Prime sentences (Experiment 1), organized by Prime Type (Active, Passive).

	Active Primes	*Passive Primes*
1	An engineer suggested a solution	A solution was suggested by an engineer
2	The intern blackmailed the politician	The politician was blackmailed by the intern
3	The children devoured the Halloween candy	The Halloween candy was devoured by the children
4	The manager assessed the situation	The situation was assessed by the manager
5	An administrator selected a candidate	A candidate was selected by an administrator
6	The mayor endorsed the bill	The bill was endorsed by the mayor
7	The employee assassinated the director	The director was assassinated by the employee
8	An audience member recommended a book	A book was recommended by an audience member
9	The pop star sand the anthem	The anthem was sung by the pop star
10	A guest stole a photograph	A photograph was stolen by a guest
11	The assistant decorated the windows	The windows were decorated by the assistant
12	The expert analyzed the problem	The problem was analyzed by the expert
13	The boys devised the plan	The plan was devised by the boys
14	The professor invented the new device	The new device was invented by the professor
15	The babysitter found the lost kitten	The lost kitten was found by the babysitter
16	The spies infiltrated the enemy camp	The enemy camp was infiltrated by the spies
17	The cat killed the cockroach	The cockroach was killed by the cat
18	A former band member threatened the musician	The musician was threatened by a former band member
19	A rival team member accosted a cheerleader	A cheerleader was accosted by a rival team member
20	The stranger approached the girls	The girls were approached by the stranger
21	The agent interrogated the suspect	The suspect was interrogated by the agent
22	The detective examined the evidence	The evidence was examined by the detective
23	The board reviewed the report	The report was reviewed by the board
24	The firemen surveyed the scene	The scene was surveyed by the firemen
25	The marines investigated the area	The area was investigated by the marines

Active Primes	Passive Primes
26 The committee planned the party	The party was planned by the committee
27 The roommates assembled the bunkbed	The bunkbed was assembled by the roommates
28 The supervisor arranged the meeting	The meeting was arranged by the supervisor
29 The acid corroded the protective coating	The protective coating was corroded by the acid
30 The girls cleaned the dirty dishes	The dirty dishes were cleaned by the girls
31 A new member created a problem	A problem was created by a new member
32 The mechanic repaired the motorcycle	The motorcycle was repaired by the mechanic
33 The secretary embezzled the funds	The funds were embezzled by the secretary
34 The deranged fan stalked the celebrity	The celebrity was stalked by the deranged fan
35 The physicist explained the theorem	The theorem was explained by the physicist
36 A student asked a question	A question was asked by a student
37 The treasurer collected the dues	The dues were collected by the treasurer
38 The mathematician calculated the answer	The answer was calculated by the mathematician
39 The lecturer sketched the diagram	The diagram was sketched by the lecturer
40 The enzyme catalyzed the reaction	The reaction was catalyzed by the enzyme
41 The forensics department analyzed the compound	The compound was analyzed by the forensics department
42 The review criticized the new author	The new author was criticized by the review
43 The file clerk intercepted the message	The message was intercepted by the file clerk
44 The mailman delivered the suspicious package	The suspicious package was delivered by the mailman
45 The doctor inspected the wound	The wound was inspected by the doctor
46 The witness accused the suspect	The suspect was accused by the witness
47 The local newspaper announced the wedding	The wedding was announced by the local newspaper
48 The attorney filed the divorce papers	The divorce papers were filed by the attorney
49 The evidence implicated the CEO	The CEO was implicated by the evidence
50 The boys repaired the old swing set	The old swing set was repaired by the boys
51 The reporter discovered the hidden records	The hidden records were discovered by the reporter
52 The FBI agent questioned the witnesses	The witnesses were questioned by the FBI agent
53 The critic reviewed the controversial film	The controversial film was reviewed by the critic
54 The artist sketched the landscape	The landscape was sketched by the artist

2. Prime sentences (Experiment 2), organized by Prime Type (Active, Passive, Unaccusative).

	Active Primes	*Passive Primes*
1	The committee was questioning the candidate	The candidate was being questioned by the committee
2	The detective was interrogating the inmate	The inmate was being interrogated by the detective
3	The rival team members were accosting the cheerleaders	The cheerleaders were being accosted by the rival team members
4	The board was investigating the scientist	The scientist was being investigated by the board
5	The babysitter was feeding the children	The children were being fed by the babysitter
6	The journalist was interviewing the musician	The musician was being interviewed by the journalist
7	The boa constrictor was devouring the rodent	The rodent was being devoured by the boa constrictor
8	The producer was firing the assistant	The assistant was being fired by the producer
9	The pediatrician was examining the children	The children were being examined by the pediatrician
10	The police were arresting the arsonist	The arsonist was being arrested by the police
11	The attorney was consulting the expert	The expert was being consulted by the attorney
12	The supervisor was organizing the participants	The participants were being organized by the supervisor
13	The intern was blackmailing the politician	The politician was being blackmailed by the intern
14	The SWAT team was rescuing the hostages	The hostages were being rescued by the SWAT team
15	The artist was contacting the gallery manager	The gallery manager was being contacted by the artist
16	The witnesses were alerting the authorities	The authorities were being alerted by the witnesses
17	The professor was nominating a colleague	A colleague was being nominated by the professor
18	The employee was assisting the director	The director was being assisted by the employee
19	The photographer was following the celebrity	The celebrity was being followed by the photographer
20	The specialist was assessing the victims	The victims were being assessed by the specialist
21	The spy was trailing the CIA agent	The CIA agent was being trailed by the spy
22	The employees were suing the CEO	The CEO was being sued by the employees
23	The mechanic was overbilling the client	The client was being overbilled by the mechanic
24	The witness was accusing the suspect	The suspect was being accused by the witness

Active Primes   *Passive Primes*

Unaccusative Primes

 1 The suspects were vanishing one by one
 2 The clients were remaining with the company
 3 The birds in the area were dying
 4 The visitors were departing
 5 The chairman was rising from his seat
 6 The firemen were leaving the scene
 7 The athlete was collapsing on the field
 8 The representative was arriving late
 9 The senator was just leaving
10 The girls were staying for the afterparty
11 The contestants were arriving on time
12 The paramedics were coming quickly

3.   Sample descriptions of target pictures. Targets used only in Experiment 1 are marked '*'; targets used only in Experiment 2 are marked '**'.

Target pictures

 1 The cobra is attacking the man *
 2 The dog is attacking the delivery man
 3 The shark is attacking the surfer
 4 The rat is biting the scientist
 5 The snake is biting the girl
 6 The wind is blowing off the girl's hat *
 7 The frog is catching a fly
 8 The cat is chasing the mouse
 9 The cops are chasing the thief
10 The dog is chasing the boy
11 The tiger is chasing the man
12 The avalanche is crushing the tractor *
13 The crane is demolishing the building
14 The tornado is destroying the house
15 The wave is destroying the sandcastle
16 The bulldozer is digging a hole

Target pictures

17 The cat is dragging the teddy bear *

18 The girl is dressing a doll *

19 The woman is dressing the baby

20 The fence is electrocuting the prisoner *

21 The baby is feeding the boy

22 The mama bird is feeding the baby birds *

23 The car is following the ambulance *

24 The helicopter is following the boat *

25 The baseball is hitting the woman *

26 The cat is hitting the skater *

27 The truck is hitting the rollerskaer *

28 The girl is kicking the clown

29 The horse is kicking the man

30 The puppy is knocking over the lamp *

31 The wind is knocking over the trashcan

32 A cat is licking another cat

33 A cat is licking the girl *

34 The girl is mailing a letter *

35 The car is pulling the cart

36 The dog is pulling the boy (in a wagon) *

37 The girl is pulling the boy (in a wagon) *

38 The horse is pulling the carriage *

39 The nail is puncturing the tire

40 The boy is pushing the girl

41 The girl is pushing the other girl (on the swing)

42 The helicopter is rescuing the baby *

43 The tank is running over the bike

44 A man is shooting a boy

45 A man is stabbing a boy *

46 A bee is stinging the girl

47 Lightning is striking the castle

48 Lightning is striking the skyscraper

49 The whale is swallowing a fish

50 The truck is towing the car

51 The alarm clock is waking (up) the boy *

Target pictures

52 The phone call is waking (up) the girl *

53 The girl is washing the baby (in a bathtub)

54 The girl is washing the boy (in a bathtub)

55 The boy is kissing the girl (on the head) **

56 The girl is hugging the boy **

57 The barber is shaving the man **

4.   Interval items (Experiment 1), organized by Interval Type (Unaccusative, Copular, Word list).

Unaccusative	*Copular*
1 The senator came late	The suitcases were heavy
2 The radioactivity decayed quickly	The garage is under the buiding
3 The trends are persisting	The supplies were in the closet
4 The bridge is collapsing	The soup was very hot
5 The goods materialized overnight	The bike is in the shed
6 The protesters left	The door was ajar
7 The missing children appeared	The drinks were cold
8 The athlete collapsed on the field	The exam was very difficult
9 The treasure disappeared	The presents are under the bed

Word list

1 injury—jacket—implication

2 journey—insight—symphony

3 mystery—canvas—liquid

4 producer—mixture—frontier

5 football—supper—fiction

6 nationalism—potential—controversy

7 fist—ballet—porch

8 mechanism—ally—suspicion

9 editorial—composition—perception

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