Affectedness and direct objects: The role of lexical semantics in the acquisition of verb argument structure*

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Abstract

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How do speakers predict the syntax of a verb from its meaning? Traditional theories posit that syntactically relevant information about semantic arguments consists of a list of thematic roles like "agent", "theme", and "goal", which are linked onto a hierarchy of grammatical positions like subject, object and oblique

object. For verbs involving motion, the entity caused to move is defined as the "theme" or "patient" and linked to the object. However, this fails for many common verbs, as in *fill water into the glass and *cover a sheet onto the bed. In more recent theories verbs' meanings are multidimensional structures in which the motions, changes, and other events can be represented in separate but connected substructures; linking rules are sensitive to the position of an argument in a particular configuration. The verb's object would be linked not to the moving entity but to the argument specified as "affected" or caused to change as the main event in the verb's meaning. The change can either be one of location, resulting from motion in a particular manner, or of state, resulting from accommodating or reacting to a substance. For example, pour *specifies how a substance moves (downward in a stream), so its substance argument is the object (*pour the water/*glass*);* fill *specifies how a container changes (from not full to full), so its stationary container argument is the object (*fill the glass/*water*). The newer theory was tested in three experiments. Children aged 3;4–9;4 and adults were taught made-up verbs, presented in a neutral syntactic context (*this is mooping*), referring to a transfer of items to a surface or container. Subjects were tested on their willingness to encode the moving items or the surface as the verb's object. For verbs where the items moved in a particular manner (e.g., zig-zagging), people were more likely to express the moving items as the object; for verbs where the surface changed state (e.g., shape, color, or fullness), people were more likely to express the surface as the object. This confirms that speakers are not confined to labeling moving entities as "themes" or "patients" and linking them to the grammatical object; when a stationary entity undergoes a state change as the result of a motion, it can be represented as the main affected argument and thereby linked to the grammatical object instead.*

Introduction

There is a strong correlation in English between a verb's semantic properties and its syntactic properties, and it seems obvious that speakers can sometimes exploit this pattern to predict form from meaning. Knowing that a verb *to glip* means "to shove with one's elbow", an English speaker can confidently guess that it is a transitive verb whose agent argument is mapped onto the subject role and whose patient ("acted upon") argument is mapped onto the object role. Thus the speaker would use the verb in *John glipped the dog* but not *The dog glipped John* or *John glipped to the dog*. There is evidence that children can do this as well (see Gropen, Pinker, Hollander, Goldberg, & Wilson, 1989; Pinker, 1984). Furthermore this procedure of *linking* (or *canonical mapping*; see Pinker, 1984) would work not only in English but in most other languages; agents of actions are

generally subjects (Keenan, 1976), and patients are generally objects (Hopper & Thompson, 1980). What is not so obvious, however, is exactly what these linking regularities are or how they are used.

Early theories: Lists of primitive thematic roles

The first theories of linking, developed by Fillmore (1968), Gruber (1965), and Jackendoff (1972), shared certain assumptions. Each posited a list of primitive "thematic roles" – such as agent, patient, theme (moving entity in a motion event), goal, source, and location – that specified the role played by the argument with respect to the event or state denoted by the predicate. These thematic roles were linked to "grammatical relations" (subject, direct object, and oblique object) according to some canonical scheme. Usually grammatical relations are arranged in a hierarchy like "subject–object–oblique" and thematic relations are arranged in a hierarchy like "agent–patient/theme–source/location/goal". Then the thematic relations specified by the verb are linked to the highest available grammatical relation (see Bowerman, 1990; Grimshaw, 1990; Pinker, 1984; for reviews). Thus a verb with an agent and a theme would have a subject and an object; a verb with an agent and a goal, or a theme and a goal, would have either a subject and an object (e.g., *enter*) or a subject and an oblique object (e.g., *go*); and a verb with an agent, a theme, and a goal (e.g., *put*) would have a subject, an object, and an oblique object.

Theories of linking based on lists of primitive thematic roles were influential in both linguistic theory (e.g., Bresnan, 1982; Chomsky, 1981) and language acquisition research (e.g., Bowerman, 1982a; Marantz, 1982; Pinker, 1984) through the first half of the 1980s, until a number of problems became apparent.

First, the early theories predict that all verbs denoting a kind of event with a given set of participant types should display the same linking pattern, and that is not true. This is especially notable among "locative" verbs that refer to an agent causing an entity (the "content" or "figure" argument, usually analyzed as a patient and theme) to move to a place (the "container" or "ground" argument, usually analyzed as a location or goal). There are some locative verbs, which we will call "figure-object" verbs, that display the standard linking pattern, where the moving entity gets mapped onto the direct object (e.g., *pour*, as in *pour water into the glass/*pour the glass with water*). Others, which we will call "ground-object" verbs, violate it (e.g., *fill*, as in *fill water into the glass/fill the glass with water*). Some others, which we will call "alternators", permit both patterns (e.g., *brush*, as in *brush butter onto the pan/brush the pan with butter*).

In some versions of the list-of-primitives theory, verbs that violate the standard linking pattern would be noncanonical or "marked" and presumably would be rarer in the language and harder to learn. Not only does this reduce the predictive

power of the theory, but its predictions do not seem to be true. Supposedly noncanonical ground-object forms may in fact be more numerous than those with the supposedly canonical figure-object syntax (Gropen, Pinker, Hollander, & Goldberg, 1991; Rappaport & Levin, 1985), and both kinds are acquired at the same time (Bowerman, 1990; Pinker, 1989). Similarly, many analyses of the dative alternation take the prepositional form (e.g., *give the book to him*) as unmarked because the theme is the object and goal is an oblique object, and the double-object form (e.g., *give him the book*) as marked because the goal is the surface object and the theme assumes a "lower" grammatical relation of second object. However, verbs taking the double-object construction are extremely common, and children do not learn the construction any later than they learn the prepositional construction (Bowerman, 1990; Gropen et al., 1989; Pinker, 1984, 1989).

A third problem with the list-of-primitives assumption is that it does not naturally explain systematic semantic differences between two forms of an alternating verb that involve the same kinds of thematic roles but different linking patterns. For example, *John loaded the cart with apples* implies that the cart is completely filled with apples, but *John loaded apples into the cart* does not. This *holistic interpretation* (Anderson, 1971) is puzzling under the list-of-primitives assumption because the arguments are labeled with the same thematic roles in both forms. This phenomenon is widely seen across constructions and languages. Across constructions we see similar semantic shifts in the difference between *Kurt climbed the mountain* and *Kurt climbed up the mountain*, only the first implying that the entire mountain has been scaled, and *Sam taught Spanish to the students* versus *Sam taught the students Spanish*, the latter suggesting that the students successfully learned Spanish (see Green, 1974; Gropen et al., 1989; Hopper & Thompson, 1980; Levin, 1985; Moravscik, 1978; Pinker, 1989; for reviews). Comparing languages we frequently find homologues to the locative alternation that involve the same kinds of verbs that alternate in English, and the holistic interpretation accompanying the ground-object form, many in languages that are genetically and areally distinct from English (Foley & Van Valin, 1985; Gropen, 1989; Moravscik, 1978; Pinker, 1989; Rappaport & Levin, 1988).

A fourth problem involves the productivity of patterns of alternation. Children and adults notice that some verbs alternate between linking patterns and extend the alternation to novel verbs. This can be seen in children's errors (e.g., *Can I fill some salt into the bear?*; Bowerman, 1982a, 1988), adults' neologisms (e.g., *fax me those data*), and children's and adults' behavior in experiments, where they are presented with sentences like *pilk the book to her* and are willing to extend it to *pilk her the book* (Gropen et al., 1989, 1991; Pinker, 1984, 1989). In standard theories this productivity is thought to be accomplished by *lexical rules*, which take a verb with its canonical linking pattern and substitute new grammatical relations (or syntactic positions) for old ones; for example, NP-V-NP$_{theme}$-*into*-NP$_{goal}$ → NP-V-NP$_{goal}$-*with*-NP$_{theme}$ (e.g. Bresnan, 1982; Pinker, 1984).

The problem is that the verb's semantic information relevant to linking should be exhaustively captured in its list of thematic roles. But the patterns of alternation (i.e., alternative linking patterns for one verb) vary among verbs with identical lists of thematic roles. While novel *fax me the message* sounds natural, equally novel *shout me the message*, with the same list of thematic roles according to the early theories, does not. Presumably some property of the individual verbs allows speakers to distinguish the alternating verbs, which can be input to a lexical rule relating it to a second linking pattern, from the nonalternating verbs, which cannot. But whatever this property is, the straighforward list-of-primitives approach is failing to capture it. It is important to know what these properties are and why they influence linking patterns. Since children are not reliably corrected for making errors like *fill salt into the bear* or *she said me nothing*, it would be mysterious how they unlearn the errors they do make and avoid the countless tempting ones they never make, unless they can detect the diagnostic properties and use them to constrain lexical rules (Baker, 1979; Gropen et al., 1989; Pinker, 1984, 1989).

Recent theories: Semantic structure

Recent theories aimed at solving these and other problems have abandoned the assumption that a verb's syntactically relevant semantic properties can be captured in a list of thematic role labels. Instead a verb is said to have a structured semantic representation that makes explicit the agentive, causal, and temporal properties of the event that the verb refers to. Thematic roles are not primitive types but are argument positions in these multidimensional structures; though certain traditional thematic labels like "agent" and "theme" can serve as mnemonics for some of these positions, the actual roles are more finely differentiated and the verb's interaction with syntax can be sensitive to such distinctions. For example, as we shall see there may be several kinds of "themes", and there may be roles that do not have traditional thematic labels. Examples of the newer theories may be found in Grimshaw (1990), Jackendoff (1987, 1991), Levin (1985), Levin and Rappaport Hovav (1991), Pustejovsky (1991), Tenny (1988), Dowty (1991), and Pinker (1989). See Levin (1985) for a review of how these theories are related to earlier theories of semantic decomposition such as generative semantics and the work of Miller and Johnson-Laird (1976).

Moreover, whereas the content of the thematic role labels in the early theories was dictated by the physical properties of the event, usually motion (so that the "theme" was always defined as the moving entity if there was one), semantic structure theories cross-classify thematic roles in terms of more elementary and abstract relations. Since the early analyses of Gruber (1965) and Jackendoff (1972) it has been apparent that events involving physical motion and events involving more abstract changes are expressed using parallel syntactic structures.

For example, *John went from sickness to health* parallels *John went from Boston to Chicago*, presumably reflecting a common level of mental representation underlying physical motion and more abstract "motion" in state space, that is, change of state. Although early theories could capture these parallels by assigning the same thematic labels to concrete and abstract motion events (e.g., *John* would be a "theme" in both of the preceding examples), they were not equipped to capture the parallels when a *single* argument of a single verb simultaneously played several kinds of roles. This is because the semantic content of each argument was exhaustively summarized in its role label, which corresponded to its role in physical motion if it participated in a motion event. The ability of an argument to play two roles simultaneously – one motional, one nonmotional – is the key to understanding constructions such as the locative, which present such severe problems for the list-of-primitives theory.

Semantic structure and the locative alternation

In their analyses of the locative alternation, Rappaport and Levin (1985, 1988) and Pinker (1989) show how the problematic noncanonicity of verbs like *fill* disappears under a more subtle analysis of their semantic structure and a more abstract theory of linking.

Say the semantic structure of *fill the glass with water* can be rendered as something like (1), which contrasts with the semantic structure of *pour water into the glass*, rendered in (2) (see Pinker, 1989, for a more formal representation):

(1) Cause the glass to become full of water by means of causing water to be in the glass.

(2) Cause water to go downward in a stream into the glass.

In (1), the semantic roles of *glass* and *water* cannot be exhaustively captured by any single thematic label. *Glass* is both an abstract "theme" or affected entity in a change-of-state event (changing from not full to full) and the "goal" in a change of location event. *Water* is both the "theme" or affected entity in a change-of-location event and helps define the state in the change-of-state event (it is what the glass becomes full of).

Furthermore the two events are related in a specific way. The state change is the "main event" and the location change is a subsidiary "means" of achieving it. This asymmetry between main and subsidiary events is motivated by dimensions of meaning that are closely related to thematic structure. In the realm of pragmatics, the choice of *fill* over *pour* serves to make the change of fullness of the glass, rather than the motion of the water, the highlighted feature of the event. (This effect is reinforced by the fact that within the rigid word order of English, the choice of *fill* focuses the content as the "new" entity by putting it at the end of the sentence, backgrounding the "given" container by putting it

immediately after the verb, and vice versa, if *pour* is used.[1]) In the realm of aspect, the event of *filling* is understood as temporally delimited at the moment that the main event is over with, namely, when the container becomes full (see Dowty, 1991; Gropen, 1989; Tenny, 1988).

Now say that there is a linking rule such as the one in (3):

(3) Link the argument that is specified as "caused to change" in the main event of a verb's semantic representation to the grammatical object.

The change or "affectedness" that is caused can either be a change of location (i.e., a motion) *or* a change of state.[2] This would correctly map the container argument of *fill* onto the object position; it is caused to change state from not full to full. The fact that it also in some sense bears the thematic role "goal" does not disrupt this mapping; since the semantic representation is a multidimensional structure rather than a single list, the "goal" relation is specified within the "means" substructure where it does not trigger the object linking rule, which distinguishes main events from means. (Instead, the goal relation triggers a linking rule for the object of the preposition *with*; the fact that it does not have a traditional thematic role label is irrelevant.)[3]

Psychologically speaking, the "semantic structure" theory renders both *pour* (traditionally canonical) and *fill* (traditionally noncanonical) as canonical, thanks to the lexicalization of a "gestalt shift" that is possible when conceptualizing

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[1]Note, however, that differences between the versions of an alternating verb cannot be *reduced* to properties of pragmatic focus. The speaker can use alternative verb structures to express differences in focus *only* to the extent that the particular verbs in the language permit it; he cannot push verbs around at will to satisfy pragmatic intentions. For example, even if the listener already knows all about a bucket becoming full and only needs to know how and with what it became full, an English speaker still may not use the semantically interpretable and pragmatically appropriate **I dripped it with maple syrup*. Conversely if the listener has background knowledge that paint has been used up but does not know how or onto what, grammar prevents the speaker from using the pragmatically natural **I coated it onto the chair*. Only for alternating verbs like *sprayed paint/sprayed the wall* can the speaker avail himself or herself of either form, depending on the discourse context. Details of the semantic representation of the phrase will necessarily differ between the forms, but will generally be consistent with the discourse difference, because differences in which entity is being asserted to be "affected" are compatible with differences in which entity is focused as "new" information.

[2]There are several other "semantic fields" such as possession, existence, or knowledge, in which a theme can be caused to change; see Jackendoff (1983, 1987, 1990) and Pinker (1989), both of which use the mnemonic "GO" to correspond to all such changes.

[3]In addition, there is a linking rule mapping the agent onto the subject; a linking rule that, in combination with other rules, maps the main event theme onto the subject if the subject has not already been linked or onto the direct object otherwise; a linking rule mapping the main event patient (i.e., an acted-upon entity, whether or not it changes) onto the direct object; and linking rules that map places, paths, and certain subordinated arguments onto oblique (prepositional) objects (see Pinker, 1989). Linking rules do not specify individual prepositions; the preposition's own semantic representation selects the appropriate kind of oblique object that it can be inserted into (Jackendoff, 1987, 1990; Pinker, 1989).

locative events. An event of filling a glass by pouring water into it can be conceptualized either as "causing water to go into a glass" (water affected) or "causing a glass to become full" (glass affected). English provides the speaker with a different verb for each perspective, and the objects of both verbs are linked to arguments with the same linking rule. The rule always picks out the affected entity in the main event, whether the affectedness involves a change of location (water for *pour*) or a change of state (glass for *fill*).

The semantic structure theory in its strongest form holds that the linking pattern of a verb is fully predictable from its meaning. At first glance this may seem circular. Since every act of moving an object to a goal is also an act of affecting the goal by forcing it to accommodate an object in some way, one might worry that the "predictability" is attained post hoc by looking at the verb's linking pattern and asserting that it means "cause to change location" just in case the moving entity is seen to be the object and "cause to change state" just in case the goal is seen to be the object. The circle is broken by a key semantic property that classifies verbs a priori as referring to change of location or change of state. Most verbs do not simply mean "move" or "change"; if they did we would have hundreds of synonyms. Rather, particular verbs mean "move in such-and-such a way" or "change in such-and-such a way". If a verb specifies *how* something moves in a main event, it must specify *that* it moves; hence we predict that for verbs that are choosy about manners of motion (but not change of state), the moving entity should be linked to the direct object role. In contrast, if a verb specifies *how* something changes state in a main event, it must specify *that* it changes state; this predicts that for verbs that are choosy about the resultant state of a changing entity (but not manner of motion), the changing entity should be linked to the direct object role. By assessing speakers' judgments about the kinds of situations that a verb can naturally refer to, we can identify which feature of the verb's meaning is specified as its main event, and predict which of its arguments is the direct object.

For example, the meaning of the verb *pour* specifies the particular manner in which a substance changes location – roughly, in a downward stream. For now it does not matter exactly how we characterize the manner in which a *poured* substance moves; what is crucial is that *some* particular manner of motion is specified in the meaning of the verb. This specificity becomes clear when we compare *pour* to closely related verbs such as *drip* and *dribble*, where equally specific, yet distinct, manners of location change are specified: an event counts as *dripping* or *dribbling*, but not *pouring*, if one drop at a time changes location. Although *pour* is choosy about how a substance moves, it is *not* choosy about the resultant state of the container or goal: one may *pour* water down the drain, out the window, into a glass, and so on. This tells us that the semantic representation of *pour* (and *drip* and *dribble*) specifies a change of location as its main event, and the affectedness linking rule, operating on the semantic representation, therefore

licenses only the figure-object form of the verb. In contrast, the meaning of the verb *fill* specifies the particular way in which the ground is affected: a container must undergo a change of state from being not full to being full. Yet *fill* does *not* specify anything about the manner in which a substance is transferred: one may *fill* a container by pumping liquid into it, by pouring liquid into it, by dripping liquid into it, by dipping it into a bathtub, and so on. Hence, the affectedness linking rule maps the semantic representation for *fill* onto the ground-object form, but not the figure-object form. Verbs like *cover*, *saturate*, and *adorn* also specify only a change of state of a ground, and they, too, can only encode the ground as direct object.

Advantages of the semantic structure theory of locative verbs

Aside from accounting for the equal naturalness and acquirability of verbs like *pour* and verbs like *fill*, the semantic structure theory has several additional advantages over the list-of-primitives theory.

For one, it jointly predicts which syntactic forms are related in an alternation, and how the verb's interpretation changes when it is linked to one form or another. In the semantic structure theory, a lexical rule is an operation on a verb's semantic structure.[4] A rule for the locative alternation converts a verb's main effect representation from "cause X to go to Y" to "cause Y to change by means of causing X to be in Y". For example, when applied to the semantic representation of *splash* in which the liquid argument is specified as affected (moving in a particular manner), the rule would generate a new semantic representation in which the target of the motion is specified as affected (covered in a particular way). The syntactic effects need not be specified directly; the linking rules automatically specify *splash water onto the wall* for the first meaning, and *splash the wall with water* for the second. The main advantage of dividing the labor of argument structure alternations between meaning-altering lexical rules and general linking rules is that the *form* of each alternative is explained. It is no longer an arbitrary stipulation that *splash water onto the wall* alternates with *splash the wall with water* rather than *splash the wall the water*, *splash onto the wall against water*, or countless other possibilities (and indeed, such forms are not to be found among children's errors; Pinker, 1989). Rather, the construability of surfaces as affected or "caused to change" entities renders the ground-object form predictable.

Moreover, because the two forms related in the alternation have similar, but not identical, semantic representations, subtle meaning differences between them – such as the holism effect – are to be expected. An alternating verb like *splash* has a slightly different meaning in the ground-object form, asserting a state

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[4]An essentially similar formulation can be found in Pesetsky (1990), who suggests that lexical alternations are morphological operations that affix a null morpheme onto a verb. The morpheme, though phonologically empty, has a semantic representation, which thereby alters the meaning of the whole affixed form.

change of the ground. Since the most natural interpretation of a state change is that it is the entire object that undergoes the change, rather than one part, the ground is interpreted holistically in this form. (The effect may in turn be related to the fact that themes in general are treated as dimensionless points in semantic structures, without any representation of their internal geometry; see Gropen, 1989; Jackendoff, 1983, 1990; Pinker, 1989; Talmy, 1983; for discussion.) This predicts that the holism requirement, because it is just a consequence of the most natural conceptualization of state changes, can be abrogated when the addition of the figure to one part of the ground can be construed as changing its state. Indeed *a vandal sprayed the sculpture with paint* is compatible with only a splotch of paint having been sprayed, presumably because here even one splotch is construed as ruining the sculpture (Dowty, 1991; Foley & Van Valin, 1984; Rappaport & Levin, 1985).

Another advantage is that the new linking theory can be applied to a variety of constructions in a variety of languages. Besides the ubiquity of the holism effect, noted above, there is a strong cross-linguistic tendency for affected entities to be encoded as direct objects. Verbs expressing events that are naturally construed as involving an agent that brings about a direct effect on a patient, such as verbs of causation of change of position (e.g., *slide*) or state (e.g., *melt*), or verbs of ingestion (e.g., *eat*), are almost invariably transitive across languages, with patients/themes as direct objects. In contrast, verbs that fall outside this broad semantic class, and allow different arguments to be construed as affected, show more variation within and across languages. For example, either argument can appear as the direct object of verbs of emotion (e.g., *fear* vs. *frighten*), and particular arguments waffle between direct and prepositional objects across verbs of perception (e.g., *see* vs. *look at*) and verbs of physical contact without a change in the contacted surface (*hit* vs. *hit at*); see Levin (1985), Hopper and Thompson (1980), and Talmy (1985). Even in these more ambiguous verbs, the new theory predicts that there should be a correlation between the linking pattern and the construal underlying the verb meaning, and this too seems to be true. For example, Grimshaw (1990) reviews evidence that *fear* and *frighten* are not synonymous but that the latter involves causation of a change in the object argument and hence its linking pattern is predictable. In sum, although languages differ as to which verb meanings they have, the linking rule for objects and affected entities may be universal. (See Pinker, 1989, for reviews of cross-linguistic surveys that suggest that abstract linking rules for subject and second object, as well as object, and the meaning changes that accompany alternations involving them, have very wide cross-linguistic applicability.)

Finally, the semantic structure theory helps explain which verbs undergo alternations. Consider the verb *stuff*, which can alternate between *Mary stuffed mail into the sack* and *Mary stuffed the sack with mail*. In order for an action to be an instance of *stuffing*, it cannot be the case (e.g.) that Mary simply dropped

letters into the sack until it was full. In fact, it wouldn't count as *stuffing* even if Mary had wadded up a few letters before dropping them in. Instead, the mail must be forced into the sack *because* the sack is being filled to a point where its remaining capacity is too small, or just barely big enough, relative to the amount of mail that is being forced in. The semantic representation of *stuff* jointly constrains the change of location that the figure undergoes and the change of state the ground undergoes. That is why the object of *stuff* can be linked either to the figure or to the ground. (We shall return to the issue of precisely how linking applies to alternating verbs.) Other alternators also denote changes or effects simultaneously specified in terms of figure and ground. For verbs like *brush* and *dab*, force is applied pushing the figure against the ground; for *load*, the insertion of a kind of contents specific to the container enables the container to act in a designated way (e.g., a camera, or a gun). See Pinker (1989) for formal semantic representations for these and other kinds of locative verbs, for evidence motivating the form of such representations, and for a discussion of precisely how they interact with linking rules.

Developmental evidence from children's errors with existing verbs

As mentioned, one of the prime challenges of the list-of-primitives theory is that children acquire the supposedly noncanonical verbs with no more difficulty than the supposedly canonical ones. The semantic structure theory is consistent with the developmental facts noted earlier because all the verbs in question are canonical. However, these data do not rule out the possibility that children create verb argument structures solely in response to examples of use of the verbs in the parental input, without deploying general mapping patterns between meaning and form. (In that case the regularities found in the adult lexicon would have to be attributed to the accumulation of individual words coined by one-time analogies during the history of the language, possibly coupled with adults noticing redundancies in their lexicons.) Better evidence concerning children's linking mechanisms comes from the study of children's errors in using verbs in syntactic structures, because errors by definition could not have been recorded directly from the input and must be the output of some productive mechanism.

Bowerman (1982a) found that children between the ages of 4 and 7 often overuse the figure-object form, as in *Can I fill some salt into the bear?* [referring to a bear-shaped salt shaker]. Errors involving incorrect ground-object forms (e.g., *I poured you with water*) also occur, but far less frequently. Both kinds of errors, and the difference in their likelihood, were also found in experiments by Gropen et al. (1991), in which 3–8-year-old children were asked to describe pictures of locative events using verbs like *pour*, *fill*, and *dump*.

Bowerman (1982a, 1988, 1990) has drawn parallels between such errors and

inflectional overregularizations of irregular verbs such as *breaked*. The child is thought to acquire many irregular verb forms from parental speech before abstracting the regular "add -*ed*" rule from pairs like *walk/walked*, and then overapplying it to the previously correct irregulars (see Marcus, Ullman, Pinker, Hollander, Rosen, & Xu, 1990). Similarly in acquiring locative verbs the child would acquire individual verbs of both the figure-object and ground-object types with the correct parental syntax, before noticing that most of them had the figure-object linking pattern. This pattern would be distilled into linking rules (of the list-of-primitives variety, though restricted to locative events) and overapplied to the ground-object verbs, resulting in errors like *fill salt*. Errors in which the opposite pattern is overapplied are presumably rarer for the same reason that inflectional errors like *brang* are less common than overregularization errors.

According to the semantic structure theory the observed asymmetry in syntactic errors could have a different source. If children are prone to making systematic mistakes about verb meaning, such as the misspecification of which entity is affected, the affectedness linking rule, even when applied correctly, would yield syntactic errors. Moreover, consistent patterns in mislearning verb meanings should lead to consistent patterns in misusing verb syntax.

Gentner (1975, 1978, 1982) has gathered evidence that children do make errors in acquiring verbs' meanings (see also Pinker, 1989, for a literature review). Furthermore some of the errors fall into a systematic pattern: children have more difficulty acquiring meaning components relevant to changes of state than components relevant to changes of location. In one experiment, Gentner (1978) tested the ability of children aged 5–9 and adults to understand common cooking terms, such as *mix*, which specifies a particular change of state ("an increase in homogeneity"), and *stir, shake*, and *beat*, which specify particular manners of motion. Subjects were asked to verify whether each of these verbs applied to events in which a mixable substance (a combination of salt and water) or a nonmixable substance (cream, already homogeneous) was shaken or stirred. Gentner found that the youngest children, but not the older children or adults, had difficulty in distinguishing appropriate from inappropriate instances of *mixing*: the 5–7-year-olds applied the verb on 48% of the trials involving mixable substances (where it is appropriate) and on 46% of the trials involving nonmixable substances (where it is not appropriate). In contrast, the same children applied the three manner-of-motion verbs on 97% of the trials in which it is appropriate, but only on 6% of the trials in which it is inappropriate.

This asymmetry in the acquisition of verb meaning components, together with the affected-entity linking rule in (3), could explain the asymmetry in syntactic error types with locative verbs noted by Bowerman (1982a) and Gropen et al. (1991): if children frequently misinterpret a state change verb as a location change verb, they will map the wrong changing entity onto the object position, resulting in figure-object errors. For example, *fill the water* might be due to the

child erroneously thinking that verbs like *fill* specify a particular manner of motion of the content argument (e.g., pouring). The prediction was tested in two experiments in Gropen et al. (1991). We showed that children between the ages of 2;6 and 8;9 not only have a tendency to make more *fill the water* (figure-object) than *pour the glass* (ground-object) errors in their speech, but they are also more likely to misrepresent the meaning of *fill* than the meaning of *pour* in comprehension. Unlike adults, they often interpreted *fill* as implying that something must be poured, even if the container ended up not full. Furthermore, there was a small tendency for the individual children who misinterpreted verbs like *fill* to be more likely to make syntactic errors with such verbs – errors in which the figure was used as the direct object.

Of course, if children are misled by the salience (to them) of the moving entity in certain locative events and mistakenly encode its manner of motion as part of the verb's meaning, they must possess a learning mechanism that at some point in development replaces the incorrect feature with the correct one. This mechanism could operate by monitoring the application of the verb *across* situations in parental speech. Sooner or later *fill* will be used by an adult to refer to an event in which there is no pouring (e.g., when a cup is filled by dripping or bailing or leaving it out during a rainstorm), so the incorrect "pouring manner" component can be expunged. But *fill* will always be used to refer to becoming full, so the state change meaning component, once hypothesized, will remain with the verb (see Pinker, 1989, for a theory outlining mechanisms of verb learning in children). If these two influences on verb learning – salience and cross-situation consistency – can be manipulated experimentally to affect speakers' construals of new verb meanings, the predictions of the semantic structure theory can be tested directly. That is the goal of the present investigation.

Developmental predictions about children's acquisition of novel verbs

We present three experiments assessing whether speakers use a verb's meaning, specifically, which argument is specified as caused to change (affected), to predict the verb's syntax. Children and adults are taught novel verbs for actions involving the transfer of objects to a surface or container. The participants are then tested on their willingness to express the figure (content) or the ground (container) argument as the direct object of the verb. The verbs are taught in a neutral syntactic context (e.g., *this is mooping*), but the meanings of the verbs are varied according to whether the figure or the ground is saliently and consistently affected in a particular way (e.g., whether the figure moves in a zig-zagging fashion, or whether the ground changes color).

According to the list-of-primitives theory, the child should assign a single thematic role to each participant in the event, drawing from the list of available

primitives. This would be "theme" for the moving entity or figure, and "goal" or "location" for the destination or ground, and they would be invariably linked to object and oblique object, respectively.

In contrast, in the semantic structure theory the child would notice the thematic roles related to motion for each of the arguments, but these roles would not exhaust the syntactically relevant semantic representation of the verb. Arguments' semantic roles could be specified on several levels of semantic representation, only one of which would correspond to the motion relations, and the linking mechanism could be sensitive to the full structure of the verb. For the events with a specific manner of motion, the figure (moving entity) and ground (destination) would be encoded as theme and goal and linked to object and *to*-object respectively, as in the primitives theory. But for events with a specific state change but without a specific manner of motion, the causation of a change of the ground would be specified in the main event, and the ground would be linked to object position by the affectedness linking rule in (3). The motion of the figure would still be specified, but in a subsidiary "means" structure, as in (1), where it would not trigger the object linking rule.[5]

The predictions of Bowerman's overregularization analogy are similar, but not identical, to those of the list-of-primitives theory. Irregular forms by definition are *unpredictable*, and can only be learned by direct exposure. For example when one comes across the archaic verb *to shend*, one cannot know that its correct past tense form is *shent* unless one actually hears it in the past tense; the regular form *shended* would be offered as the default. According to the overregularization analogy, this would be true for ground-object verbs as well, and it predicts that a child should generally assign figure-object syntax to a novel locative verb if it is heard without syntactic cues, regardless of the kind of locative event it refers to. In addition, the analogy predicts some smaller proportion of uses of ground-object syntax, matching the asymmetry of errors observed in spontaneous speech, which in turn would be related to the smaller fraction of existing verbs in the language that display the ground-object pattern.

Experiment 1

In the first experiment we teach children one novel verb with the intended construal "cause X to move to Y in a zig-zagging manner", and another with the intended construal "cause Y to sag by means of placing X on it". We did not invent verbs with both a manner and a state change. On the one hand, if such a

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[5]The subordinated figure argument can either be left unexpressed, as an "understood" argument, or expressed as the object of the preposition *with*. The distinction, not studied in this investigation, is discussed in Jackendoff (1987), Rappaport and Levin (1988), and Pinker (1989).

verb involved an unrelated manner and state change (c.g., "to cause X to zig-zag over to Y, causing Y to sag") it would not be linguistically possible and psychologically natural, because real verbs cannot specify multiple events unless they also specify some causal relation between them (Carter, 1976; Pinker, 1989, Ch. 5). On the other hand, if the verb involved an interpredictable manner of motion and resulting state change, the theory predicts it should alternate, and thus any mixture of figure-object and ground-object responses would be compatible with the theory and its prediction would be unclear.

The verbs are presented in a context like "this [acting out] is keating". Note that this construction involves a gerund form rather than an intransitive use of the verb, and that gerunds do not require arguments to be expressed. For example, English verbs that are obligatorily transitive can easily appear in the gerund form, as in "This [acting out or pointing] is devouring". Thus the grammatical context does not leak any grammatically relevant information to the subjects.

Method

Subjects
Sixty-four native English speakers participated: 16 children between 3;4 and 4;5 (mean 3;11); 16 between 4;7 and 5;11 (mean 5;1); 16 between 6;5 and 8;6 (mean 7;5); and 16 paid undergraduate and graduate students at MIT. The children were drawn from middle-class day-care and after-school programs in the Boston area. Eight children who failed to understand the taught verbs or were confused, distracted, or shy, were replaced in the design.

Materials
In a pretest, we used a cup and some marbles. In the experiment, to discourage subjects from making rote responses we used two separate pairs of materials: a clear packet of pennies was moved to a 20-cm felt square, or a packet of marbles was moved to a plastic square. During the teaching and testing phases, the cloth or plastic was placed on a stand consisting of either a solid square, which supported its entire surface, or a hollow frame, supporting only its perimeter.

Two verb meanings were created. In the *manner* condition, a packet was moved to a fully supported piece of material in a zig-zagging manner. In the *endstate* condition, the packet was moved in a direct path to an unsupported piece of material, which sagged under the weight of the packet. By using the same pairs of materials for both actions (within subject), we ensured that any differences in performance were not due to the salience of the materials. Corresponding to these two novel actions were two verb roots, *pilk* and *keat*. The pairing of one of the meanings with one of the roots that defined each verb was counterbalanced across subjects within each age group.

Procedure

Children were tested in a quiet area by two experimenters, one eliciting responses, the other recording data. Each novel verb was introduced to children by a puppet as a "puppet word".

Pretest. After being introduced to the materials, subjects were pretested on sentences with the verbs *pour* and *fill*. They were shown examples of pouring and filling, and descriptions were elicited; the experimenter recorded whether they used the figure (marbles) or ground (cup) as the direct object. For example, the experimenter would say: "do you know the word *fill*? . . . when I do this (moving marbles, a few at a time, into a cup) . . . and it ends up like that (the cup filled) . . . it's called *filling*." After doing this three times, the experimenter asked, "using the word *fill*, can you tell me what I'm doing?" If a subject failed to produce a sentence with an unambiguous direct object, we followed up with a prompt: "filling what?" or "filling ____?"[6] Regardless of the subject's final response, the experimenter modeled a correct sentence with *fill* (i.e., *I'm filling the cup with marbles*), and had the subject repeat it. The analogous protocol was followed for *pour*. The order of pretesting the two verbs was counterbalanced across subjects within an age group.

Teaching the novel verbs. Each subject was then taught two novel verbs: one specifying a manner (zig-zagging) and the other specifying an endstate (sagging). The verbs were taught and elicited one at a time, order counterbalanced across subjects in an age group. The experimenter first asked, "Can you say *keat*? . . . say *keat*," and then said, "let me show you what *keating* is . . . when I do this [moving a packet directly towards an unsupported square] . . . and it ends up like that [placing the packet onto the square, causing it to sag] . . . it's called *keating*." After repeating the demonstration, the experimenter said, "now let me show you something that's *not keating* . . . when I do this [moving a packet towards a *supported* square] . . . and it ends up like that [placing the packet onto the square, without changing its shape] . . . it's *not* called *keating*." The experimenter then asked, "Can you show me what keating is?" and then "Can you show me something that's not keating?" If children failed, the experimenter again showed examples and non-examples of the verb's meaning, and had the child act out the verb again, using the same materials. The teaching protocol was repeated with the second pair of materials.

The same teaching procedure was used when teaching the manner-of-motion verb. The experimenter moved a packet onto a supported square in a zig-zagging

[6] If subjects still failed to respond, the procedure called for a forced-choice question (e.g., "Am I filling the cup or filling the marbles?", order counterbalanced. However, we had to resort to a forced-choice question on only four occasions in this investigation (0.2%), so we have grouped these data with those given in response to the fill-in-the-blank prompt.

manner, saying, "when I do this . . . and it ends up over there . . . it's called *pilking*". To illustrate what the verb was not, the experimenter then moved the packet in a bouncing manner.[7]

Testing the novel verbs. After each verb was taught, sentences containing it were elicited. The experimenter reverted to the original set of materials, asked the child to act out the verb again, asked him or her for the name of the figure (marbles or pennies), supplying it if the child did not, and asked him or her to say the verb. Then the experimenter asked, "Can you tell me, with the word *keating*, what I'm doing with the *marbles*?" while performing the action. The experimenter then verified that the child knew the names of the second set of materials, and elicited a sentence with it with a slightly different question: "Can you tell me, using the verb *keating*, what I'm doing with the *cloth*?" We posed the question these two ways to guard against the possibility that the subjects had a constant preference for either the figure-object or ground-object form, masking any potential effect of verb meaning. The figure question is a discourse context that makes the figure-object sentence pragmatically natural as a reply, and similarly the ground question makes a ground-object sentence natural (this technique was also used in Gropen et al., 1989, 1991, and in Pinker, Lebeaux, & Frost, 1987). Since both questions were asked with both verbs, order counterbalanced, this did not introduce any confound. In those trials where a subject failed to provide an unambiguous direct object, we followed up with a prompt: "keating what?" or "keating ____?"

The second verb was then taught and tested with the same protocol. Both pairs of materials were used in the teaching and syntactic testing of each verb, with the sequence of materials switched for the second verb (within subject) and balanced across subjects within an age group. In addition, we also switched the order of question types so that the sequence of items mentioned in the questions was either figure–ground–ground–figure or ground–figure–figure–ground. Together, these switches guaranteed that the same two items (i.e., marbles and felt or pennies and plastic) were mentioned in questions for both verbs within subject, so that the focusing of different materials in the questions could not account for any

[7]Note that the difference in instructions between manner and state-change verbs does not provide syntactic information that the child can use to predict the syntactic differences between the verbs. In most grammatical theories, *over there* and *like that* are both prepositional phrases. In particular, *like* in this context is not an adjective: adjectives do not take direct objects, only prepositional phrases and clauses; prepositions do take direct objects, but do not take the comparative *-er* suffix; cf. *A is liker B than C*. The fact that *over there* refers to a location (semantics typical of a PP) and *like that* refers to a state (semantics typical of an AP) is syntactically irrelevant: PPs can refer to states (e.g., *in this state; with red paint all over it; in a mess*) and APs can refer to locations (e.g., *very close to the edge; closer to the edge*). Of course, children could be attending to the semantics of the phrases in the instructions, instead of or in addition to their real-world referents, but this is fully compatible with the intention that the independent variable be one of verb semantics. Crucially, the syntactic difference between the instructions provides no information of use to the child.

differences in a subject's performance with the two meanings. Furthermore, the combination of verb meaning, question order, and material order was counterbalanced across subjects in each age group.

Scoring

Responses containing the appropriate verb and an unambiguous direct object were scored according to whether the object consisted of the figure or the ground in the action. Responses that were made only in response to the follow-up prompt (e.g., "keating what?") were also tallied separately. When subjects used a pronoun (e.g., "you're keating it"), utterances were counted only if the referent was disambiguated by the presence of an oblique object or particle (e.g., "you keated it onto the felt" or "You keated it on"), or if the referent could be pinned down via the subsequent prompt. In addition, we noted spontaneous intrusions of English verbs and unsolicited descriptions of the actions.

Results and discussion

Table 1 presents the proportions of figure-object and ground-object responses for the manner and endstate verbs, broken down by the type of eliciting question. Responses to the original question and to the subsequent prompt are combined in the proportions reported in this and other tables presented in this paper. The actual frequencies of unprompted and prompted responses (collapsed across question types) are also reported in the tables.

Table 1.   *Experiment 1: likelihood of choosing figure or ground arguments as the direct object of manner and endstate verbs*

| | Age | | | | | | | | | |
| Object argument: | 3;4–4;5 | | 4;7–5;11 | | 6;5–8;6 | | Adult | | Mean | |
	Figure	Ground	Figure	Ground	Figure	Ground	Figure	Ground	Figure	Ground
Manner verbs										
Figure question	1.00	0.00	1.00	0.00	1.00	0.00	0.88	0.06	0.97	0.02
Ground question	0.88	0.12	0.94	0.06	0.69	0.31	0.62	0.31	0.78	0.20
Mean	0.94	0.06	0.97	0.03	0.84	0.16	0.75	0.19	0.88	0.11
No prompt/prompt	6/24	2/0	8/23	0/1	17/10	5/0	20/4	6/0		
Endstate verbs										
Figure question	0.94	0.06	0.88	0.12	0.75	0.19	0.69	0.31	0.81	0.17
Ground question	0.56	0.38	0.69	0.31	0.38	0.62	0.44	0.56	0.52	0.47
Mean	0.75	0.22	0.78	0.22	0.56	0.41	0.56	0.44	0.66	0.32
No prompt/prompt	7/17	4/3	12/13	3/4	11/7	10/3	16/2	14/0		

A small number of unscorable responses caused some sets of proportions not to add up to 1.00 and some sets of frequencies not to add up to 32.

As predicted, children in all age groups, and adults, produced more figure-object responses when using manner verbs than when using endstate verbs, and produced more ground-object responses when using endstate verbs than when using manner verbs.

In principle, the frequencies of figure-object and ground-object responses are independent because children could fail to provide an unambiguous sentence of either type; this calls for separate analyses of the proportions of figure-object and of ground-object responses. In practice, however, ambiguous responses were rare (less than 0.5% across the three experiments), so a single number for each condition suffices to summarize the subjects' behavior. The number we chose to enter into the analyses of variance is the proportion of trials in which a figure-object form was produced. Subjects produced significantly more figure-object responses in the manner condition (mean proportion = 0.88) than in the endstate condition (0.66), $F(1, 60) = 20.59$, $p < .001$. The difference was also significant for the mid-aged children, $F(1, 15) = 5.87$, $p < .03$, and the oldest children, $F(1, 15) = 6.36$, $p < .03$, and marginally so for the youngest children, $F(1, 15) = 4.36$, $p < .06$, and the adults, $F(1, 15) = 4.36$, $p < .06$. Finally, because of a set carried over from the first verb taught to the second, the verb type effect was stronger (between subjects within each age group) for the first verb taught ($F(1, 56) = 22.40$, $p < .001$) than for the second ($F(1, 56) < 1$).

The analysis of variance also revealed a significant main effect of question type, showing that subjects were sensitive to discourse influences on object choice. They produced more figure-object sentences (and thus fewer ground-object sentences) when the figure was mentioned in the question than when the ground was mentioned, $F(1, 60) = 31.68$, $p < .001$. No other effect or interaction was statistically significant.

Although we have shown that the choice of direct object is influenced by the aspect of the situation that the verb meaning specifies, with more figure-object responses and fewer ground-object responses for manner-of-motion verbs than change-of-state verbs, figure-object responses were in the majority for both types of verbs. We found a similar overall preference in the pretest using existing verbs: 11 of the youngest children, 3 of the middle group, and 4 of the oldest group (but no adults) produced ungrammatical sentences in which the direct object of *fill* was the content argument, and none made the converse error with *pour* (see also Bowerman, 1982a; Gropen et al., 1991). Part of this preference may be attributed to an overall bias for young children to attend to manners over endstates, as documented by Gentner (1978) and Gropen et al. (1991): the linking rule would translate a bias towards the manner components of verb meaning into a preference for figure-object sentences. Indeed our choice of endstate verb may, inadvertently, have fostered such a bias. The experimenter often had to nudge the packet into the unsupported material in order to initiate the sagging, and subjects may have noticed this, thereby interpreting the action that we have been calling

"change of state" as involving a particular manner as well. That is, the verb may inadvertently have been given the interconnected motion-and-state-change semantics of an alternator like *stuff* or *brush*. In fact, of the 16 children who provided overt descriptions of the meaning of the endstate verb by focusing on one of the arguments, 10 mentioned what happened to the figure (most often, that it moved downward), contrary to our intentions.

Experiment 2

In this experiment we teach children and adults a purer endstate verb. The problem with the endstate verb in Experiment 1 was that the state change was a change of shape, and by definition whenever an object changes shape its local parts must change position. To cause a change in the position of the local parts of the ground object, the figure object had to impinge on it in a particular way, and that particular way (nudging) may have been interpreted by the subjects as part of the verb meaning, rendering it an alternator and diluting the predicted effect. Here we will teach a verb in which the ground changes color, not configuration, and furthermore the proximal cause of the change is chemical, not the motion of an impinging figure. If the linking hypothesis is correct, ground-object constructions should be the response of choice in using these endstate verbs.

Method

Subjects
Sixty-four native English speakers, drawn from the same sources as in Experiment 1, participated: 16 between 3;5 and 4;5 (mean 3;10); 16 between 4;7 and 5;8 (mean 5;1); 16 between 6;7 and 8;5 (mean 7;3); and 16 adults. We replaced one child in the design for being unresponsive in the syntactic task, three children because of experimenter error, and one adult who was color-blind.

Materials
As in Experiment 1, two separate pairs of materials were used with each subject, though in this experiment the pairing of objects (figures) and surfaces (grounds) was balanced across subjects in an age group. The surface was either a 6×10-cm piece of absorbent paper or a piece of white felt; the object was either a 2-cm square piece of sponge or a cotton ball. All materials were kept damp: the surface was saturated with cabbage juice; the object was saturated with either water, lemon juice, or a baking soda solution. As in Experiment 1, a cup and some marbles were used in a pretest.

Two verb meanings were created, both involving taking a damp object and patting it against a damp surface. For the endstate verb, the surface changed color

in an acid-base reaction from purple (the color of unadulterated cabbage juice) to either pink (when the object contained lemon juice) or green (when the object contained baking soda solution). In the manner condition, an object was moved to a surface in a particular manner, either zig-zagging or bouncing; the object was saturated with water so no color change resulted. The color of the change and the particular manner were consistent for each subject and counterbalanced across subjects. As in the previous experiment, we used the same pairs of materials for both actions (within subjects). Corresponding to these two novel actions were two verb roots, *moop* and *keat*. The pairing of verb meanings and verb roots was counterbalanced across subjects in an age group.

Procedure

The procedure and scoring were the same as in Experiment 1, except that when providing a demonstration of what the endstate verb did not refer to, the experimenter used the solution that produced the other color. In addition, in order to reduce the carry-over effects in Experiment 1 caused by questioning the same materials for both verbs, we made the following changes: the sequence of materials for the first verb was counterbalanced with the sequence for the second verb, the order of question types for the first verb was counterbalanced with the order for the second verb, and the total sequence of materials and the total sequence of question types were combined so that each material (object or surface) was mentioned in only one question per session, and each material (in a given pairing) was mentioned an equal number of times in a question within meaning condition (all counterbalancings are over subjects within each age group).

Results and discussion

Results are shown in Table 2. As predicted, subjects responded with more figure-object sentences for manner verbs than for endstate verbs. An analysis of variance on the proportion of figure-object responses reveals a significant difference for the two verb types, $F(1, 60) = 115.52, p < .001$. (The effect is even larger when examined between subjects using only the first verb taught, eliminating carry-over effects.) The difference between the two verb types does not just arise from responses to the follow-up prompts, but is observed for full sentence responses to the original question; $F(1, 60) = 17.55, p < .001$. The effect of verb type is significant within each age group: youngest children, $F(1, 15) = 9.00$, $p < .01$; middle children, $F(1, 15) = 90.00, p < .001$; oldest children, $F(1, 15) = 27.21, p < .001$; adults, $F(1, 15) = 30.77, p < .001$. We also replicated the effect of discourse focus seen in Experiment 1, in which subjects produced relatively more figure-object forms when the figure was mentioned in the question than when the ground was mentioned, $F(1, 60) = 10.00, p < .005$.

Table 2.   *Experiment 2: likelihood of choosing figure or ground arguments as the direct object of manner and endstate verbs*

| Object argument: | Age | | | | | | | | | |
| | 3;4–4;5 | | 4;7–5;8 | | 6;7–8;5 | | Adult | | Mean | |
	Figure	Ground	Figure	Ground	Figure	Ground	Figure	Ground	Figure	Ground
Manner verbs										
Figure question	0.62	0.38	0.88	0.12	0.81	0.19	0.69	0.31	0.75	0.25
Ground question	0.44	0.56	0.62	0.38	0.69	0.31	0.62	0.38	0.59	0.41
Mean	0.53	0.47	0.75	0.25	0.75	0.25	0.66	0.34	0.67	0.33
No prompt/prompt	1/16	5/10	1/23	1/7	9/15	4/4	15/6	11/0		
Endstate verbs										
Figure question	0.19	0.75	0.00	1.00	0.25	0.75	0.00	1.00	0.11	0.88
Ground question	0.12	0.81	0.00	1.00	0.06	0.94	0.00	1.00	0.05	0.94
Mean	0.16	0.78	0.00	1.00	0.16	0.84	0.00	1.00	0.08	0.91
No prompt/prompt	3/2	5/20	0/0	5/27	2/3	14/13	0/0	29/3		

A small number of unscorable responses caused some sets of proportions not to add up to 1.00 and some sets of frequencies not to add up to 32.

What is noteworthy in these data is that in each age group figure-object sentences were in the majority for the manner verb whereas ground-object sentences were in the majority for the endstate verb. (Indeed the 4–5-year-old children and the adults expressed the stationary entity as the direct object 100% of the time when it was observed to change state.) The results show that when a change of state is salient enough, children will usually express this affected entity as a direct object, even though it would traditionally be analyzed as a "goal" to which some other "theme" in the scene is moving. (Indeed, it is possible that when children correctly grasp that the meaning of a verb involves a change of state, they *always* choose the ground-object form: the 33 children (69%) who spontaneously used a color name to explain the meaning of the endstate verb produced nothing but ground-object sentences, though we cannot rule out the possibility that both phenomena are due to general precociousness.) Interestingly, the pretest revealed the same kind of error patterns with existing verbs that have been found in previous studies: 17 children out of 48 (10, 4, and 3 from the respective age groups) incorrectly used *fill* with the ground as direct object, and only one child made the complementary error with *pour*. Thus the tendency to make errors like *fill water* does not reflect the operation of a general requirement that figures be linked to the direct object position.

Experiment 3

In this experiment we attempt to explain the holistic interpretation that accompanies alternating locative verbs such as *load* and *spray*, whereby in ground-object

sentences like *John loaded the cart with apples* the ground is interpreted as being affected over its entire surface or capacity, whereas in figure-object sentences like *John loaded apples into the cart* no such interpretation is forced (Anderson, 1971; Schwartz-Norman, 1976). If the holism effect is a consequence of the fact that a state change is naturally conceptualized as applying to an entire entity, and of a rule that links entities changing state to the grammatical object, then surfaces or containers that are completely covered or filled should be more likely to be construed as affected, and thus more likely to be expressed as direct objects, than those that are only partly covered or filled.

We contrast a "partitive" condition, in which (e.g.) a peg is inserted into a hole on a board, with a "holistic" condition, in which the same action is repeated until all of the holes on the board are plugged with pegs. We predict that children and adults should produce more ground-object sentences with the verb in the holistic condition than with the verb in the partitive condition.

Method

Subject

Sixty-four native English speakers, drawn from the same sources as in the previous two experiments, participated: 16 between 3;5 and 4;10 (mean 4;0); 16 between 5;0 and 6;11 (mean 5;7); 16 between 7;0 and 9;4 (mean 7;10); and 16 adults. We replaced five children in the design for being uncooperative, inattentive, or shy, one child because of experimenter error, one child for having received contaminating intervention, and one adult for misinterpreting the task as a request to imitate a child.

Materials

Two sets of materials were used with each subject, each consisting of two types of objects and two containers. One set consisted of beads, 0.6-cm plastic eggs, a flatbed cart with six holes in its 8 × 20-cm surface, and a 10-cm square cube with four holes on one of its sides. The second set consisted of marbles, small plastic balls, an 8 × 20-cm bench with six holes, and an 8 × 60-cm board with four holes. Both kinds of objects in a set could be inserted part way into the holes of either container in that set. Each subject saw the same pairings of objects and containers, counterbalanced across subjects in an age group. In addition, two (non-interchangeable) pairs of materials were used in the teaching phase: 5-cm styrofoam disks and a muffin tray with eight cavities; and 3 × 3-cm Duplo pieces and a candy mold with 12 indentations.

Because the comparison in this experiment involves a single kind of action, performed either once or enough times to fill all the holes in a container, a between-subjects design was necessary: each subject was taught and tested on one

verb meaning. Across subjects in an age group, the partitive meaning was taught and tested as often as the holistic meaning, and the mean ages of the children in different meaning conditions were matched to ±2 months for each age group. In addition, we counterbalanced the four possible combinations of objects and containers with verb meaning so that each combination of object–container pairs occurred as often in the partitive condition as it did in the holistic condition, across the subjects in an age group. The verb root *keat* was used throughout.

Procedure

After introducing the subject to the materials and verb form, the experimenter taught the verb by performing the holistic or partitive action once, using either the styrofoam and muffin tray or the Duploes and candy mold. In the partitive condition, the experimenter inserted (e.g.) a piece of styrofoam into a hole in the tray while saying "I am keating." In the holistic condition, the experimenter inserted (e.g.) styrofoam pieces into the tray, one at a time, until all of the holes in the tray were plugged. The description "I am keating" was uttered only once, but the utterance was stretched out while the experimenter inserted several pieces. The experimenter then asked the subject to "show me what keating is." The teaching sequence was repeated on the rare occasions when it was necessary.

In eliciting sentences, we sought to increase the number of prepositional phrases uttered by making it pragmatically informative to include them (see Crain, Thornton, & Murasugi, 1987; Gropen et al., 1991). Subjects saw two types of objects or two types of containers, only one of which actually participated in the event, and had to describe the action to a blindfolded puppet. For example, when asking a ground question in the holistic condition, the experimenter would say "Here is a board . . . I can have either some marbles (pointing) . . . or some balls (pointing). Now watch this: I am keating (filling the board with the marbles) . . . Tell Marty the puppet, using the word *keat*, what I did to the *board*." The most natural response in this context is a full ground-object form, (e.g.) "You keated the board with the *marbles*," where the old information (topic) is encoded as the direct object and the new information is encoded as the prepositional object. Similarly, when asking a figure question in the holistic condition, the experimenter would say (e.g.) "Here are some marbles . . . I can have either a board (pointing) . . . or a bench (pointing). Now watch this: I am keating (filling the bench with the marbles) . . . Tell Marty, using the word *keat*, what I did to the *marbles*." The order of presentation of the two materials was balanced within subject so that the chosen material was first as often as it was second. The same procedure was used for the partitive action except that single objects were moved and named. As before, the question was followed, if necessary, with the prompt "keating ____?" or "keating what?"

Four of these questions were asked in each of two blocks of elicitation trials, in

the order figure–ground–figure–ground or ground–figure–ground–figure. Each presentation of the novel action was performed with a new pair of materials, so that after four trials each of the four objects and containers had been used once. The procedure for the second block was the same as for the first, except that the experimenter reinforced the temporal endpoint of the events by saying, "I am done keating. I keated" after each presentation of an action. We counterbalanced the sequence of question types for the first and second blocks, and coordinated the total sequence of question types with the total sequence of material pairs so that each of the eight materials was mentioned in a question exactly once per session, and each material (in a given pairing) was mentioned as often in the partitive condition as it was in the holistic condition (all counterbalancings are over subjects within each age group). After each block of trials, the experimenters administered several procedures designed to assess and train children's understanding of the temporal unfolding of the event. Since the results of these procedures had no measurable effect on the second block of elicitation trials, we will not discuss them; details are reported in Gropen (1989).

The responses were scored as in Experiments 1 and 2. Acceptable ground-object forms included one passive (*the block was keated*) and two sentences in which the figure was encoded as an instrumental subject (e.g., *the bead keated the block*).

Results and discussion

Table 3 shows the proportions of figure-object and ground-object responses (collapsing across both blocks of elicitation trials) for the partitive and holistic

Table 3.   *Experiment 3: likelihood of choosing figure or ground arguments as the direct object of partitive and holistic verbs*

| | Age | | | | | | | | | |
| | 3;5–4;10 | | 5;0–6;11 | | 7;0–9;4 | | Adult | | Mean | |
Object argument:	Figure	Ground	Figure	Ground	Figure	Ground	Figure	Ground	Figure	Ground
Partitive verbs										
Figure question	0.88	0.12	0.88	0.12	0.78	0.22	0.84	0.16	0.84	0.16
Ground question	0.84	0.16	0.88	0.12	0.69	0.31	0.72	0.28	0.78	0.22
Mean	0.86	0.14	0.88	0.12	0.73	0.27	0.78	0.22	0.81	0.19
No prompt/prompt	5/50	4/5	40/16	7/1	45/2	13/4	45/5	11/3		
Holistic verbs										
Figure question	0.81	0.19	0.59	0.41	0.69	0.31	0.84	0.16	0.73	0.27
Ground question	0.47	0.53	0.31	0.69	0.69	0.31	0.56	0.44	0.51	0.49
Mean	0.64	0.36	0.45	0.55	0.69	0.31	0.70	0.30	0.62	0.38
No prompt/prompt	25/16	18/5	16/13	30/5	42/2	18/2	45/0	18/1		

verbs. As predicted, subjects used more ground-object forms when the verb referred to a holistic action (ground completely filled) than when referring to a partitive action (ground partly filled). The comparison is significant in an analysis of variance whose dependent variable is the proportion of figure-object responses; $F(1, 56) = 4.36$, $p < .05$. The actual effect consists of subjects strongly preferring the figure-object sentence with partitive verbs, but being indifferent between figure-object and ground-object sentences with holistic verbs. This can be seen in a set of two-tailed t-tests: for partitive verbs, the difference between proportions of figure-object and ground-object responses is significantly different from zero in every age group except the oldest children: young children, $t(7) = 3.29$, $p < .02$; middle children, $t(7) = 3.00$, $p < .025$; oldest children, $t(7) = 1.69$, $p = .14$; adults, $t(7) = 2.61$, $p < .05$. In contrast, the difference between proportions of figure-object and ground-object responses in the holistic condition is not significantly different from zero for any of the age groups.

As in previous experiments, subjects produced relatively more figure-object forms when the figure was mentioned in the question than when the ground was mentioned, $F(1, 56) = 16.55$, $p < .001$. A significant interaction of verb meaning and question type indicates that the effect of question type is greater in the holistic condition than in the partitive condition, $F(1, 56) = 5.33$, $p < .05$. This reflects a tendency for subjects to avoid the ground-object form of the partitive verb, even in response to a ground question, but to respond to the ground question with a ground response for holistic verbs.

We have shown that children interpret completely filled or covered surfaces as more worthy of being expressed as the direct object of a novel verb. This manifests itself most strongly as an outright avoidance of ground-object sentences when the surface is only partly filled. This is exactly what we would expect if speakers respected the holism constraint, according to which ground-object sentences imply holistic effects, and hence partitive effects imply the avoidance of ground-object sentences. In other words, subjects should avoid saying (e.g.) *you keated the board with the ball* in the partitive condition for the same reason that English speakers avoid saying *Mary loaded the cart with the apple(s)* in the situation where most of the cart remains empty. In contrast, it is not unnatural to say *Mary loaded apples into the cart* or *Mary put apples into the cart* even when she fills it. This is consistent with our finding that subjects did not avoid uttering figure-object sentences in either condition.

General discussion

The three experiments clearly show that children (from 3 to 9) and adults, when faced with a locative verb and no syntactic information about how to use it, show no across-the-board tendency to express the caused-to-move or figure entity as the

direct object. Rather, when the goal of the motion changes state, whether it be shape (Experiment 1), color (Experiment 2), or fullness (Experiment 3), speakers are more likely to select that goal as the direct object.

These findings add developmental evidence to the list of problems recently recognized as plaguing earlier theories of linking such as those of Gruber (1965), Fillmore (1968), and Jackendoff (1972), where a verb's syntactically relevant semantic argument structure consists of a single set of thematic roles drawn from a fixed list and determined on the basis of motion if the verb refers to motion. It supports the more recent theories (e.g., Dowty, 1991; Grimshaw, 1990; Jackendoff, 1987, 1990; Pinker, 1989; Rappaport & Levin, 1985, 1988; see Levin, 1985, for a review) that posit a multilayered semantic structure in which information about motion, other changes, and their causal relations are specified, and in which linking rules are triggered by arguments in specific semantic sub-structures. Specifically, we have demonstrated the operation of a linking rule that interprets "themes" as entities that are "caused to change" or "affected" as part of the verb's main event representation, and maps them onto the direct object position, whether the change be location, state, or something else. Thus even when a learner registers that a verb can refer to a salient motion along a path to a goal, this motion event does not exhaust his or her syntactically relevant semantic representation of the verb; if there is a consistent state change serving as the end to which the motion is merely a means, the motion can be represented in this subordinate role, and the state change, as superordinate main event, can trigger the linking to direct object.

The results reinforce a theory that helps to explain many properties of English and other languages: why different verbs (e.g., *pour* and *fill*) have seemingly different linking patterns, the prevalence and lack of markedness of verbs whose moving entities are not objects, and the nonsynonymity (holism effect) of constructions with alternating verbs. Indeed the psycholinguistic foundation of the holism effect – that a state is most naturally predicated of the object considered in its entirety – was directly demonstrated in Experiment 3, where subjects, knowing only that a surface was holistically affected, were likely to describe the event with novel verbs using ground-object syntax.

In its strongest form the semantic structure theory predicts that verbs' syntactic argument structures are completely predictable from their semantic representations, for all verbs, speakers, ages, and languages. For many years this proposition has seemed clearly false, given the seemingly arbitrary differences between verbs within and across languages, and the existence of children's errors. The semantic structure theory, however, posits a richness and fine grain to verbs' semantic representations that might render the extreme claim defensible. All differences in syntactic argument structures should be accompanied by subtle, though measurable differences in semantic structure. In the next section we discuss how the theory would characterize such an interplay between syntax and semantics.

How are linking rules used in language?

According to the version of semantic structure theory discussed here, linking rules are not isolable bits of knowledge particular to a language, like a vocabulary item or rule of morphology, but are an inherent part of the interface between lexical semantics and syntactic argument structure. Thus they should have pervasive (though indirect) effects coordinating the semantics and syntax of predicates. In this section we examine these effects as they might operate in the experiments reported here and in the language acquisition process.

1. In the experiments

In all three experiments we influenced the syntactic privileges that subjects assigned to a novel verb presented with no syntactic information: children (in each age group) and adults were more likely to express the stationary goal entity as direct object (and less likely to express the moving entity as direct object) when the goal entity underwent a change of shape, color, or fullness than when it stayed the same and an entity moved to it in a characteristic fashion.

However, one might wonder (as did one of the reviewers of an earlier version of this paper) whether the semantic structure theory should predict that *all* of the uses of state-change verbs should have the ground as the direct object, and all of the uses of the manner verbs should have the figure as the direct object. This would be true only if we could have controlled subjects' construal of the verb *completely* in the few demonstrations of its meaning we were able to present (and, of course, if we could have prevented all lapses of attention, forgetting, idiosyncratic interest in the nonspecifically changing entity, response bias, and carry-over effects), which is not practical. In a person's real-life experience, any inappropriate construal of a verb's meaning as including some irrelevant semantic dimension (e.g., manner for an endstate verb or vice versa) can be expunged as the person witnesses the verb being used in circumstances that lack that feature, as noted. But even with our brief teaching situations, we were able to find a consistent significant effect in the predicted direction superimposed on the various uncontrollable factors. Moreover, the partial dilution of the effect, especially in Experiment 1, is understandable from independent sources of evidence, such as the manner bias demonstrated by Gentner (1978) and Gropen et al. (1991) and the partially faulty, alternator-like semantics of the verb we designed. In Experiment 2, where the endstate verb was better designed, children of all ages and adults preferred to express the stationary ground surface as the direct object, a preference that was absolute for two of the groups. (Of course, since subjects are literally free to construe a wetted surface as "affected" even if it does not change color or any other feature, we could not prevent them from ever using the ground-object form in the manner condition.) In Experiment 3, previous examination of the range of meanings allowed by existing alternating verbs helped make

sense of the magnitudes of effects obtained: both figure-object and ground-object forms are compatible with a holistic event, but a partitive event lacking any obvious state change should strongly bias a choice of the figure-object form.

Furthermore, an experiment reported in Gropen (1989) is consistent with our conjecture that some nonpredicted sentences in these studies were lawful consequences of subjects' construing events in ways we could not completely control. The experiment was similar to the holistic condition of Experiment 3 except that subjects were also asked whether the event was best described as *putting* or *covering*. This was thought to assess in part their uncontrolled personal construals of the event as kinds of motions (for which *put* would be the most appropriate existing verb) or kinds of changes (for which *cover* would be most appropriate). Subjects (3;7 to adult) who chose *cover* preferred the ground-object form 91% of the time when using the novel verb; subjects who chose *put* preferred it only 61% of the time.

2. Novel coinages

The real-life case closest to our experiments is one where a speaker coins a novel verb (or interprets such a novel coinage by another speaker for the first time). Such coinages can occur when stems are invented out of the blue, perhaps influenced by phonetic symbolism (such as the recent verbs *snarf* (retrieve a computer file), *scarf* (devour), *frob* (randomly try out adjustments), *mung* (render inoperable), and *ding* (reject)). They can also occur when a stem is borrowed from another lexical category (e.g., *He tried to Rosemary-Woods the tape*; *He nroffed and scribed the text file*; see Clark & Clark, 1979). In all such cases the argument structure of the novel verb is not predictable from existing forms in the language and must be created from the verb's meaning by linking rules.

3. Recording a verb used in a sentence

Whenever a verb is heard in a grammatical syntactic construction, there is, strictly speaking, no need to use a linking rule to predict that the verb can appear in that construction; that fact can be recorded directly from the input. However, the fact that verbs obey linking regularities so uniformly suggests that linking rules do play a role in their acquisition, unlike genuinely input-driven memorization such as irregular morphology or the association between a word's sound and its meaning.

The prediction of the semantic structure theory discussed in this paper is that the child must make a verb's syntax (observed from syntactic analyses of parental sentences) compatible with its semantics (observed from the sets of situations in which the verb is used) according to the linking rules. Thus children should have trouble learning verbs whose hypothesized semantic representations are incompatible with their syntax, such as an English verb meaning something like "pour" but with the syntax of *fill* or vice versa.

Furthermore when a child hears a verb used in a full sentence, he or she could use the linking rule in the reverse direction, to guide the acquisition of the verb's meaning by directing attention to features of meaning that reliably accompany the verb but that may otherwise have gone unnoticed. For example, if an argument is heard in direct object position, the child may try out the hypothesis that the verb specifies that it is affected. The child would verify whether the referent reliably changes when used with the verb, and if it does, he or she could look for some characteristic manner if it moves, or state change if it does not, and would add it to the semantic representation of the verb. See Gleitman (1990) and Pinker (1989) for discussion and evidence.[8]

Finally, note that even when a child witnesses the syntactic privileges of a verb, he or she may forget them, but if the meaning is remembered the linking rules can reconstruct them. See Pinker (1989, pp. 330–341) for a discussion of verb errors in children's spontaneous speech that suggests that this process does occur.

4. Generalizing a verb from one construction to another

The most common setting where a speaker may be expected to apply linking rules productively is in generalizing from one construction that a verb is heard in[*] to a new, related construction. For example, a learner might be faced with generalizing from a figure-object form of an alternating verb like *daub paint on the board* to a ground-object verb form like *daub the board with paint*, or vice versa, in the absence of having heard one of the two forms. See Gropen et al. (1989), Bowerman (1988), and Pinker (1984, 1989) for reviews of experimental and naturalistic evidence that adults and children frequently make such generalizations.

Within the semantic structure theory, these generalizations are enabled not by a single lexical rule specifying the syntactic linking of the new form (as in the list-of-primitives theory), but by a combination of a specific lexical rule and general linking rules (Pinker, 1989; Rappaport & Levin, 1988). The lexical rule is reduced to a simple manipulation of a verb's semantic structure, effecting a gestalt shift: the rule takes a semantic representation like "cause X to go into/onto Y" and generates a new, related representation like "cause Y to change by means of causing X to be in/on Y" (or vice versa). The linking rules would create the corresponding syntactic structures automatically. As mentioned in the Introduction, this division of labor helps explain the forms of the syntactic structures that are related by an alternation, the change of interpretation (e.g., holism) that

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[8]Note that this is distinct from the proposal of Landau and Gleitman (1985) and Gleitman (1990) that the child must use a *set* of argument structures to deduce the idiosyncratic semantic content of the verb (e.g., whether the verb refers to *opening, closing, breaking,* or *melting*) from those argument structures, without having to note the contexts in which the verb is used. Pinker (1989) and Grimshaw and Pinker (1990, in preparation) examine this particular proposal in detail, and discuss evidence suggesting that it is unlikely to be an important factor in learning lexical semantics.

accompanies it, and its verbwise selectivity. If this characterization of a lexical rule as a simple semantic operation is correct, it would mean that linking rules are used whenever a verb is extended to a new construction for the first time.

Note, though, that the lexical rule cannot be applied freely to just any locative verb. If it could, a nonalternating motion verb like *pour* could be the basis for the creation of a similar verb predicating a state change resulting from pouring (something like "be poured upon"), and the linking rule would generate the ungrammatical ** pour the glass with water*. True, we pointed out in the Introduction that alternating verbs like *stuff* and *spray* are generally different from nonalternators in simultaneously constraining properties of the figure and ground arguments in their definitions, but this raises the question of why non-alternators like *pour* and *fill* cannot have secondary meanings, involving simultaneous figure and ground constraints, that would make them eligible for the construction that they do not, in fact, appear in.

Pinker (1989) and Gropen et al. (1989), drawing on Levin (1985) and Green (1974), suggest that lexical rules apply freely only within narrowly circumscribed subclasses of verbs within the broad class that is generally associated with an alternation. For example, the English locative rule applies freely not to all verbs involving motion of contents to a container or surface, but only to verbs of simultaneous contact and motion (e.g., *smear, brush, dab*), vertical arrangement (*heap, pile, stack*), ballistic motion of a mass (e.g., *splash, spray, inject*), scattering (e.g., *scatter, strew, sow*), overfilling (e.g., *stuff, cram, pack, wad*), and insertion of a designated kind of object (*load, pack, stock*). Virtually all other locative verbs, those that fall outside of these subclasses, are confined to one syntactic form or the other. For example verbs of enabling the force of gravity (e.g., *pour, dump, drip, spill*) are confined to the figure-object construction, and verbs of exact covering, filling, or saturating (e.g., *fill, cover, line, coat, soak, drench*) are confined to the ground-object form.[9]

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[9]Goldberg (in press) suggests that once one specifies narrow subclasses of verbs belonging to a construction, one can eliminate lexical rules. The speaker could note that a verb has an intrinsic meaning that is compatible with more than one possible subclass and could use it in both accompanying constructions; constraints on alternations would reduce to constraints on possible verb meanings. See Pinker (1989, Ch. 4) for three reasons why lexical rules seem to be necessary. (1) They specify morphological changes accompanying certain alternations (e.g., English passive). (2) They dictate the semantic composition of verb meaning and construction meaning (e.g., distinguishing whether the semantic representation of a verb in one construction is a "means" or an "effect" in the representation in another construction). (3) They specify pairs of compatible semantic subclasses that are allowed to share verb roots, distinguishing them from pairs of compatible semantic subclasses that are confined to disjoint sets of verb roots. For example, verbs of "removing stuff from a surface" and "making a surface free of stuff" can share roots, as in *clean (clear, strip) the table of crumbs/crumbs from the table*, presumably because of a lexical rule. But verbs of "removing possessions from a person" and "making a person bereft of possessions," though both possible in English, must be expressed by different roots, as in *seize (steal, recover, grab) money from John/*John of his money; bilk (rob, relieve, unburden) John of his money/*money from John* (see Talmy, 1985), presumably because of the absence of a lexical rule.

Presumably the child learns the subclasses by focusing on a verb that he or she hears alternate in parental speech, and generalizing its meaning to a minimal extent. This has the effect that a subsequently encountered verb that is highly similar in meaning will be allowed to alternate as well. See Pinker (1989) for a precise definition of "highly semantically similar" and for formal details of the generalization mechanism and how it interacts with verbs' semantic representations.

5. Development of alternating subclasses in acquisition and history

There is one effect of linking rules on the language whose mode of psychological operation is not clear, and this is in motivating the *kinds* of semantic subclasses that are freely subjectable to lexical rules in a given language, that is, the kind of constraints discussed in the immediately preceding passage. It seems that which subclasses of verbs actually alternate in the language correlates with the cognitive content of the notion "affectedness": the easier it is to construe both the figure and the ground as directly "affected" by a given action, the more likely English is to allow verbs of that type to alternate. For example in verbs like *brush* and *dab*, force is applied simultaneously to the figure and the ground, an action easily construable as affecting them both. Similarly, what makes an event an instance of *stuffing*, *cramming*, or other verbs in the overfilling subclass is that force is applied to the contents in opposition to resistance put up by the container. The difference between the gravity-enabled motion subclass (*pour*, *spill*, *drip*, etc., which cannot be used in the ground-object form) and the imparted-force subclass (*splash*, *spray*, *inject*, *splatter*, etc., which alternate) may be related to the fact that when force is imparted to a substance the location and shape of the goal object is taken into account by the agent in how the force is imparted (e.g., in aiming it), and the particular pattern of caused motion defining the verb also predicts the effect on the goal (e.g., the kind of motion that makes an act *splattering* or *injecting* also dictates how a sprayed surface or injected object has changed. See Pinker, 1989, and Gropen, 1989, for explicit semantic representations of all these verbs.)

Why do English constraints on alternation show signs of having hints of a cognitive motivation? It is certainly not true that the ease of construing an event as simultaneously affecting figure and ground is the *direct* cause of a speaker's willingness to allow a verb to alternate. That is because there are stable constraints within a dialect, and differences between dialects, in the specifications of the exact subclasses of verbs that can alternate. (For example, we cannot say *drip the cake with icing* even if we construe the cake as directly affected, though some English speakers can; see Pinker, 1989; Rappaport & Levin, 1985.) Instead, presumably the psychology of affectedness interacts with psycholinguistic rules of the locative alternation in more indirect ways. Over historical timespans innovative speakers may be more likely to extend a verb subclass to a new construction

for the first time if the intrinsic semantics of the verbs in the subclass is cognitively compatible with the semantics of the construction (e.g., if the object argument in the new construction is easily conceptualized as being affected). And perhaps these innovations are more likely to spread through a linguistic community if many members of the community find it tempting to construe the event in the multiple ways originally entertained by the innovator. Finally, once the subclass becomes entrenched as a possible domain of a rule, it might be more easily learned by each generation if the construals it forces on the speakers are cognitively natural (see Pinker, 1989, for discussion).

6. Bootstrapping the first rules involving grammatical relations

A final implication of the semantic structure theory of linking concerns the semantic bootstrapping hypothesis (see Grimshaw, 1981; Macnamara, 1982; Pinker, 1982, 1984, 1987, 1989; Wexler & Culicover, 1980). According to this hypothesis, young children at the outset of language acquisition (younger than those studied here) might use linking regularities and word meanings to identify examples of formal syntactic structures and relations in parental speech and hence to trigger syntactic rule learning for their particular language. (This is logically independent of the claim that linking rules are used to predict *individual* verbs' syntactic privileges from their meanings after the rules of syntax for their language have been acquired.) For example, if the patient argument of a verb comes after the verb in an input sentence, the child can deduce that it is a VO language, even if the child had no way of knowing prior to that point what counted as an object in that language.

A major sticking point for the hypothesis has been the existence of seeming counterexamples to any proposed set of linking rules: for example, passives, in which the agent is not expressed as a subject, and double-object datives and ground-object locatives, where the argument traditionally analyzed as the "theme" or "patient" is not expressed as the verb's first object. The hypothesis required that parents avoid using the supposedly exceptional constructions in their speech, that the child recognizes them as exceptional by various cues, or that the child weighs and combines multiple sources of evidence to settle on the most concordant overall analysis of the construction (see Pinker, 1982, 1984, 1987, for discussion).

But if linking rules, when properly formulated, are exceptionless, the burden of filtering "marked" or "noncanonical" or "exceptional" constructions out of the input to rule-learning mechanisms is shifted. If objects are linked from "affected" or "caused to change" entities, not necessarily "moved" ones (and if subjects can be linked not only from agents but from themes in agentless semantic structures; see Pinker, 1989), then neither the child nor the parent would have to pay special attention to using or analyzing the supposedly "marked" constructions. The restriction instead is that the parent would have to use predicates whose semantic

structures meshed with the young child's construal of the situation; the universal linking rules, shared by parent and child, would yield the correct syntactic analysis for the child as long as the child could identify (e.g.) which entities counted as "affected". Obviously, it is not realistic to expect that the lexical semantics of a parent's verb matches the child's cognitive representation of the described event for all situations and languages. But the fact that the new linking theory allowed us to predict the syntactic frames that children assigned to novel verbs in specific kinds of situations, including frames often treated as "marked", suggests that some sharing of construals between child and adult is plausible.

Appendix: A comparison of the semantic structure theory of linking with Melissa Bowerman's overregularization analogy

Bowerman (1990) presents an interesting discussion of the possible operation of linking rules in children's first word combinations (the 2–5-word strings produced before the age of 2). She first points out that though word order errors are not infrequent in the speech of her two daughters (about 11% of the utterances she reproduces in her tables) the errors do not seem to occur more often for verb argument structures that would be harder according to the list-of-primitives theory (e.g., double-object datives or ground-object locatives). Nor do the first correct uses of these marked constructions appear later than their supposedly unmarked counterparts. These data were among those we mentioned in the Introduction as posing a challenge to the list-of-primitives theory.

Bowerman notes that the semantic structure theory defended in this paper does not predict the same asymmetry. But she presents additional tests that, she claims, refute the newer theory as well – in particular, the hypothesis that the child's language system is innately organized to link verbs' syntactic and semantic representations in particular ways. Instead, she argues that children are not predisposed to follow any particular pattern of linking. At first they acquire verbs' syntactic properties individually from the input, and they are capable of acquiring any linking pattern between arguments and syntactic positions with equal ease. When the child notices statistically predominant linking patterns in the verbs thus acquired, the patterns are extracted as rules and possibly overextended, like inflectional overregularizations (e.g., *breaked*). As support for this proposal she cites evidence that children's use of linking rules appears only late in development (presumably after the child has had enough time to tabulate the linking patterns) and that their errors mirror the relative frequencies of the linking patterns among verbs in the language.

In this Appendix we will first outline the logic of testing for the existence of linking rules, then turn to Bowerman's two empirical tests (one claimed to refute the existence of innate linking rules, the other claimed to support the overregularization analogy); finally, we examine the overregularization analogy itself.

The logic of testing for linking rules in early speech

Linking rules, under the conception outlined here and in Pinker (1989) and Gropen (1989), are internal pointers between lexical semantic structures and grammatical relations, and hence cannot be tested directly against children's behavior, but only together with independently motivated hypotheses about each of the structures that the linking rules would link. In the experiments reported in this paper and in Gropen et al. (1991), such motivation was readily available. It seems safe to assume that in experimental subjects 3;4 and older, basic grammatical relations like object and oblique object are well developed. In the experiments reported here, we attempted to control lexical semantic structures directly, as part of our experimental manipulations; in Gropen et al. (1991), we exploited the bias previously demonstrated by Gentner (1978) and others (see Pinker, 1989, for a review) whereby children acquire manner-of-motion components of meaning more easily than change-of-state components.

Bowerman's data are far more problematic as tests for the existence of linking rules, because neither of the two entities that the linking rules would link is reliably present in the children's speech. First, there is some evidence from Bowerman herself that the girls' first meanings for several common verbs were not true semantic representations but could be quite context-bound. In Bowerman (1978, p. 982) she argues that their first uses of *put, take, bring, drop*, and *make go* "were restricted to relatively specific, and different, contexts" with the result that each child "may be at a loss when she wants to refer to a new act that does not fit clearly into any of these categories." This raises the possibility that many early verbs (including "nonprototypical" verbs) could be used correctly simply because they were memorized as referring to stereotyped situations and kinds of arguments. Linking rules, which apply to more schematic verb semantic structures that can refer to a particular range of situations, may not be applicable until such semantic structures are acquired, which Bowerman (1978) suggests often comes later. Second, the errors in this early state do not appear to involve linking per se, where the wrong arguments would be linked to particular grammatical positions like subject, object, or the object of particular prepositions. Rather, the errors include every possible distortion of the grammatical positions themselves: SOV, VOS, VSO, OSV, and OVS orders all occur. The ordering of subject, verb, and object is not a linking phenomenon (specific verbs do not call for SVO order; it is general across the English language), and so these errors probably reflect noisy processing or incomplete acquisition in components of the child's language system involving phrase structure and grammatical relations.[10]

But for now, let us assume that the correct utterances in Bowerman's sample

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[10]Bowerman notes that the errors occur more often for prototypical agent–patient verbs than for "other" verbs, but this pattern, if general, would be difficult to explain in any theory.

involve properly represented grammatical relations and semantic structures, so that we can focus on the logic of her tests comparing different kinds of verbs.

Bowerman does not outline any specific proposals about young children's semantic representations, but points to a discussion in Pinker (1989) on the mechanisms by which verb meanings are acquired. Pinker (1989) describes three plausible (and not mutually exclusive) mechanisms. One is called event-category labeling: the child would take a pre-existing concept of a particular kind of event or state (e.g., seeing, or breaking) and use it as a hypothesis about the meaning of a verb inferred to express an instance of such an event. In general this mechanism can serve as no more than a source of first or default hypotheses; however, because many verbs corresponding to a general cognitive category like "moving an object" or "fright" vary in their precise semantic representations across languages (Gentner, 1982; Pinker, 1989; Talmy, 1985). The second learning mechanism is called semantic structure hypothesis testing: the child would add or delete substructures to his or her current representation of a verb meaning to make it conform with instances of its use. (For example, if a child incorrectly represented *fill* as requiring a pouring manner, that meaning component would be dropped when the verb was heard in connection with bailing.) The third learning mechanism is called syntactic cueing, in which the child would create semantic substructures with a set of inferences including the use of linking rules in reverse. That is, when the child hears a verb used in a sentence at a point at which enough syntax has been acquired to parse the sentence, the child would adjust the semantic representation of the verb to make it compatible with the grammatical relations of the verb's arguments, in conformity with the linking rules. For example a child who thought that *fill* meant "to pour" would change its semantics upon hearing *fill* used with a direct object referring to a full container, which implies that the verb expresses the change undergone by the container argument. Note that the subsequent use of linking rules does not care about which (if any) of these procedures was used to acquire a verb's semantic representation, as long as the verb has one.

Bowerman extracts a prediction from the operation of these mechanisms. She first lists verbs for which event-category labeling would be a sufficient learning mechanism; in particular, "prototypical agent–patient verbs" such as *open, fix, throw away, wash,* and *eat* should be prominent examples of such "cognitively-given" verbs. These verbs are then contrasted with stative transitive verbs such as *like, scare* (with an inanimate subject), *see, hear, need,* and *want,* where general cognitive concepts are associated with verbs that show variation in linking within and across languages (e.g., fright can be expressed with either *fear* or *scare*). She notes, "Regardless of which technique the child uses to determine the mapping of 'non-cognitively-given' verbs, it is clear that these verbs will require more effort than verbs whose meanings are cognitively transparent. Cognitively transparent verbs can in principle be mapped immediately (because there is only one

candidate Agent, Patient, etc.); in contrast, 'something more' is needed for ambiguous verbs, and this will take extra time." But her two daughters did not use prototypical agent–patient verbs any sooner, or with fewer errors, than the "non-cognitively-given" verbs.[11]

Note, however, that Bowerman's prediction relies on an extra and gratuitous assumption. While it is true that "something more" is needed to acquire ambiguous verbs compared to unambiguous ones, that something more is not, as she suggests, "effort", or even time, but *information*. The semantic representation of an unambiguous verb could be acquired as a default by category labeling even if the child did no more than witness the verb itself expressing a single instance of the relevant event or state; for ambiguous verbs, a syntactic context or a disambiguating situation or situations would be required. But the difference is simply one of availability of information, not of inherent difficulty or time consumption other than that entailed by the difference between no information and some information. And crucially, because these are naturalistic data, the child surely *has* had access to relevant information. If a child is uttering *scare* or *like* at all she has necessarily heard those verbs used previously. If she has heard them used previously she has almost certainly heard them in contexts providing information that resolves their thematic ambiguity. One kind of context is situational: while the general event/state category pertaining to fright may be ambiguous, *to scare* involves an event and *to fear* a state (Dowty, 1991; Grimshaw, 1990; Pesetsky, 1990), and a situation in which *scare* is used to refer to an event can disambiguate them. The other kind of context is sentential: the child surely has not learned the verb from sentences like "this is scaring" but from sentences where the verb appears with a subject and an object, identifiable on many occasions as referring to either the experiencer or the stimulus. Here the syntax could cue the child, via reverse linking, to select a semantic representation of *scare* involving a causal stimulus argument. Similarly , there is no reason why it should be hard to acquire consistent semantic and syntactic representations for other "non-cognitively-given" verbs in Bowerman's list, like *ride, hold, spill, drop, wear, see, hear*, and *like*, as long as the child does not hear them in isolation but in correct sentences with their usual referents.

Thus Bowerman has not tested linking rules by themselves (which is generally impossible) but in conjunction with the extra asumption that *even with information sufficient to resolve thematic ambiguities* verbs whose meanings require the use of hypothesis testing or syntactic cueing have a lasting disadvantage compared

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[11] In some cases, Bowerman's assignment of verbs to her "prototypical agent–patient" class may not exactly fit the criterion of verbs that show little variation in linking: *hit* and *cover* are classified as prototypical agent–patient verbs, though they do vary across languages (see her Note 7); for some excluded verbs, such as *hold* and *draw*, it is not clear that they do vary. Still, the patterns shown by the two children would not change much if a few verbs were recategorized.

to verbs that could have been acquired by category labeling. Note that Bowerman needed this extra assumption so that she could use her naturalistic data to test a hypothesis that is inherently better suited to being tested experimentally. According to the semantic structure theory of linking, together with the assumption that category labeling exists as one of the mechanisms for acquiring semantic structure, the ambiguous and unambiguous verbs should differ only when no disambiguating information is available. This situation is impossible to achieve in everyday life, but easy to achieve (at least in principle) in an experiment: an experimenter can present novel verbs without any syntactic context, controlling the events and states it refers to, and test whether children use the verbs with predictable syntax. Of course, that is exactly what we did in this paper with older children. A related experiment can be done by presenting novel verbs in syntactic contexts that linking rules render flatly incompatible with any reasonable semantic representation (verbs with "anticanonical" linking, where, for example, the direct object is an agent and hence not construable as "affected"), and seeing if children have more trouble learning them. This has been done with older children by Marantz (1982) and Pinker et al. (1987).

If verbs without a pre-existing concept corresponding precisely to their meanings can develop through experience without measurable disadvantage, one might wonder whether the role of linking, especially in semantic bootstrapping, has been minimized, or worse, defines a vicious circle (verbs' syntactic properties are deduced by linking rules applied to their semantic representations, verbs' semantic representations are acquired by reverse linking from syntax). The issues are discussed in detail in Pinker (1987, 1989, Ch. 6). The circle is easily broken by the fact that the verbs that inspire the hypothesization of grammatical rules are not the *same* verbs that need to be acquired with the help of their grammatical contexts; even a few unambiguous verbs would be sufficient in principle to get grammar acquisition started.[12] Moreover, no matter what the relative contributions are of nonlinguistic concepts, patterns of use across situations, and syntactic cues in how a verb was originally acquired, linking rules will govern its syntactic expression and semantic interpretation thereafter in a variety of spheres, such as refinement of its semantic representation, participation in lexical alternations, innovative uses including those leading to historical change, and holistic interpretation, as outlined in the General discussion.

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[12]Note that Bowerman's data also do not test the semantic bootstrapping hypothesis, which asserts the prototypical semantic relations are cues used to hypothesize rules involving grammatical relations (which can then be used for all verbs, regardless of semantics), not that the rules themselves are specific to particular kinds of semantic relations. Semantic bootstrapping, like linking, is best tested experimentally: children hearing a language containing only situationally ambiguous or anticanonical verbs would have trouble learning its grammar; see Pinker (1984, Ch. 2).

Are children's linking errors strongly input driven?

Bowerman presents independent evidence in support of her claim that linking regularities must be acquired completely from parental speech. She suggests that errors attributable solely to linking rules (i.e., where the language does not contain lexical alternations, like the locative, that allow the appearance of a verb in one construction to predict its appearance in a related one via a lexical rule) occur only late in development, presumably after the child has tabulated enough data. Specifically, errors where experiencer-subject psychological verbs are used with stimulus subjects (e.g., *It didn't mind me very much*), reflecting the majority pattern in English, do not occur until the 6–11-year age range in Bowerman's two daughters.

Upon wider examination the data pattern provides little if any support for the hypothesis, however. Because lexical alternations are ubiquitous in English, Bowerman was able to rule out many possible examples of linking on the grounds that an existing English alternation might have been the source. But this does not mean that the alternation in fact was the source. In Hebrew, there are no verbs that can be used in identical form in causative and intransitive constructions, but Berman (1982) notes that 2-year-old children acquiring Hebrew use intransitive verb forms as causative transitives with agent subjects and theme objects, just as English-speaking children do. Moreover, even in English young children use verbs with nonadult but appropriate linking patterns that could not have been analogized from existing alternations. For example, Bowerman herself (1982b) presents 14 examples where children, as young as 2, causativized transitive verbs to form double-object structures (e.g., *I want to watch you this book*). This pattern of alternation is for all practical purposes nonexistent in English (Pinker, 1989). Most strikingly, the particular transitive verbs that children incorrectly link to the double-object construction are just the kinds of verbs that legitimately appear in that construction in a great variety of languages (Pinker, 1989), suggesting a common underlying psychological bias in linking. (See Pinker, 1984, Ch. 8, and Pinker, 1989, Chs. 1 and 7, for other examples of linking errors that are not based on existing English lexical alternations.)

Finally, let us examine Bowerman's data on psychological verbs, consisting of nine errors from her two daughters. One has an experiencer subject, the minority pattern in English. Of the eight with stimulus subjects, one consists of a sequence of two incorrect forms and a correct form: *I am very fond. Everyone's fond of me. I am very fonded.* Note that the second incorrect form in this sequence is a passive whose active verb source would *not* differ in linking from the correct English form (experiencer subject); the error is in converting an adjective to a passive. The other incorrect form in the sequence may also have been intended as a passive, given that the child followed it with nonpassive and clearly passive recastings of

the predicate with the linking pattern it would have if it were indeed a passive, and given children's tendency to leave forms ending in *t* or *d* unmarked in past and participle forms (see Pinker & Prince, 1988). Even if it was intended as a nonpassive adjective, its experiencer subject follows no common English linking pattern for such predicates. A third example is a double-object form (*You know what pictures me uncle?*), which does not occur at all in English with stimulus subjects verbs. Three others are intransitive with prepositionally marked stimulus arguments (*approved to you; reacted on me; picture to me like*), of which the great majority in English actually have experiencer subjects; there are only a tiny number with stimulus subjects (*appeal, matter*; Talmy, 1985; Beth Levin, personal communication). This leaves only three errors containing transitive usages with stimulus subjects, reportedly the majority pattern in English, out of the nine linking errors with psych verbs listed. Thus when the grammatical properties of the errors and of English verbs are examined with more precision, one finds no clear evidence for Bowerman's assertion that most children's errors follow the statistically dominant linking pattern for English psychological verbs.

Do alternative linking patterns act like irregular inflection?

Bowerman gives no explicit account of how her alternative learning mechanism works or how its operation predicts developmental patterns or linguistic regularities. But the guiding analogy, inflectional overregularization, seems more misleading than helpful when examined in detail (see Marcus et al., 1990; Pinker & Prince, 1988). First, whereas irregularly inflected verbs are fewer in number and higher in average token frequency than regular ones, the exact opposite may be true of ground-object and figure-object locative verbs (Rappaport & Levin, 1985; Gropen et al., 1991). Second, verbs fall into inflectional paradigms specifying a past tense form for every verb, in which the presence of an irregular is sufficient to block the regular rule. This allows the child to recover from inflectional overregularization when he or she hears the irregular a sufficient number of times. But no such paradigm organization is apparent for locative argument structures and the overregularization analogy leaves the unlearning of such errors unexplained (Gropen et al., 1991; Pinker, 1989). Third, whereas any particular irregular pattern occurs with an unpredictable set of verbs (by definition), the ground-object linking pattern occurs *predictably* with verbs having a particular kind of meaning (in children as well as adults). Fourth, whereas any particular irregular pattern is an arbitrary memorization and supports no further grammatical inferences, the ground-object form is lawfully associated with a particular shift in interpretation (in children as well as adults), the one we have referred to as "holistic". Fifth, whereas the child's course of acquiring irregular verbs is mainly governed by frequency of exposure (since the verbs' unpredic-

tability requires them to be memorized by rote; see Marcus et al., 1990), the developmental course of ground-object forms is influenced by specific, independently measurable aspects of their semantic development (Gropen et al., 1991). Sixth, while particular irregular patterns and the verbs they take vary radically from language to language, the ground-object form and the verbs that use it show highly similar patterns across unrelated languages. A learning mechanism that recorded any statistically predominant linkage between figure versus ground and direct versus oblique object predicts that these widespread and mutually consistent patterns should not occur. In contrast, it would be shocking to find an *i–a* alternation in the past tense inflection of the translations of *sing* in language after language, other than those historically close to English. The fact that these linking patterns do occur counts as evidence against Bowerman's claim that children learn the syntactic argument structure of verbs like *fill* in the same way that they learn the past tense forms of verbs like *sing*.

In sum, we find Bowerman's data interesting in suggesting that, in the presence of linguistic and nonlinguistic contextual information, young children can acquire verb representations even if the verbs do not unambiguously label preformed concepts for kinds of events, states, and arguments. But we see two problems in her claim that children learn all aspects of linking from the statistics of parental speech, with all possible linking patterns being equally easy to acquire. Methodologically, she tries to exploit her naturalistic data to test a hypothesis that can only be tested clearly with experimental materials in which a verb's semantic and syntactic contexts can be manipulated. Theoretically she appeals to the metaphor of irregular morphology; we have shown that when one examines the linguistic and psychological facts in detail, the metaphor falls apart. The ground-object form is just not an example of linguistic irregularity.

Note that we are not suggesting that learning plays a small role in the acquisition of argument structure. The child must learn details of the semantic structures of individual verbs, the kinds of verb structures permitted in the language, and which kinds of verbs lexical rules apply to. But the evidence suggests that linking rules, which show little or no cross-linguistic variation and which enforce pervasive systematicities among these learned structures, are more plausibly seen as one of the causes of such learning rather than as one of its products.

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