



Understanding how input matters: verb learning and the footprint of universal grammar

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Received 18 April 2001; received in revised form 11 January 2002; accepted 17 September 2002

Abstract

Studies under the heading “syntactic bootstrapping” have demonstrated that syntax guides young children’s interpretations during verb learning. We evaluate two hypotheses concerning the origins of syntactic bootstrapping effects. The “universalist” view, holding that syntactic bootstrapping falls out from universal properties of the syntax–semantics mapping, is shown to be superior to the “emergentist” view, which holds that argument structure patterns emerge from a process of categorization and generalization over the input. These theories diverge in their predictions about a language in which syntactic structure is not the most reliable cue to a certain meaning. In Kannada, causative morphology is a better predictor of causative meaning than transitivity is. Hence, the emergentist view predicts that Kannada-speaking children will associate causative morphology (in favor of transitive syntax) with causative meaning. The universalist theory, however, predicts the opposite pattern. Using an act-out task, we found that 3-year-old native speakers of Kannada associate argument number and not morphological form with causativity, supporting the universalist approach.

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Keywords: Word learning; Causatives; Kannada; Input; Syntactic bootstrapping; Universal grammar

1. Introduction

How do children acquire the vocabulary of their language? Two conclusions about the child’s acquisition of a first lexicon are obvious from the outset of inquiry. First, the words are learned as a tight function of the input, for children manifestly learn French words from French input and Igbo words from Igbo input. Second, the learner plays an active role, weakening and distorting any “simple” description of the input–output relation. It is hope-

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less, for example, to suppose that learning is responsive (solely) to input frequency, because the first word in the English vocabulary is not *the*. Some “theory of the child” is necessary, then, to bring the facts about the input – how adults speak to children – and the facts about the output – how children speak – into some sort of responsible alignment. This alignment is what linguistic theory is designed to be about (Chomsky, 1965). Understanding how environment and nature in this sense come together to explain the course and outcome of language learning is a crucial question. Indeed, it is the only question worth asking in this domain given that children’s exposure to a language is finite and limited, and yet they come to say anything they choose (or at least anything they can get away with). In the present paper, we examine the effects of input and output in understanding a particularly revealing subcomponent of lexical learning: the child’s acquisition of the verb vocabulary. Two features of verb learning, which we now discuss in turn, make this a particularly appealing testbed for comparing learned (input-responsive) and unlearned (learner-driven) aspects of language acquisition.

2. Structural correlates of verb learning

As is now well attested, the verbs of the exposure language are acquired in lockstep with acquisition of those features of the clause-level grammar having to do with the relation between a verb’s semantic argument structure and its syntactic structure. Children who understand the English verb *swim* appreciate that it prototypically involves only a single participant and surfaces as an intransitive; it takes two participants for an act of *killing*, however, and so this verb is transitive; as for *giving*, because it involves three entities (the giver, the givee, and the given), it usually surfaces as a ditransitive, e.g. *Max gave a ham sandwich to Pat*.

This coincidence of structural and semantic learning poses a classic chicken–egg problem, with some authors arguing that syntax (at this level) provides a fundamental guide to young children’s interpretations of the verbs they are learning (Bloom, 1999; Fisher, 1996; Fisher, Hall, Rakowitz, & Gleitman, 1994; Gleitman, 1990; Landau & Gleitman, 1985; Naigles, 1990) and others averring that argument structure patterns emerge from generalizations made after significant item-based learning (Goldberg, 1999; Tomasello, 2000).

So stated, these positions need not be and have not usually been interpreted as in direct conflict. Instead, many authors have emphasized complementary (or “trade-off”) relations between acquisition of the verb meanings and their associated syntactic properties (see, e.g. Bowerman, 1982; Gillette, Gleitman, Gleitman, & Lederer, 1999; Pinker, 1984, 1989). But examined more closely, two currently viable hypotheses concerning the acquisition of this form–meaning interface reflect starkly differing viewpoints about the nature of children and thus about their language learning. On the “universalist” view, the correlation between lexical and syntactic development falls out from universal properties of the mapping between syntax and lexical semantics (Gleitman, 1990; Lidz, 1998a; Lidz, Gleitman, & Gleitman, 2001; cf. Pinker, 1989). According to this view, many argument structure patterns do not have to be learned independently of the syntax of the language. The alternative, “emergentist”, view holds that the relations between argument structure and syntactic structure are learned through a process of categorization and generalization over

the input (Goldberg, 1999; Tomasello, 2000). According to the strongest version of this latter view, the syntax–semantics patterns could have been anything at all but, whatever they turn out to be in any single language, the child will pick up the patterns via inductive distributional learning. More weakly interpreted, the patterns themselves may reflect linguistically natural or preferred tendencies of encoding, but still these patterns play no direct role in the learning process itself. In our experiments, we will examine this issue by asking what happens in child language learning under conditions in which a particular language masks the preferred form–meaning correlations.

3. Abstractness and lexical learning

In the literature of “syntactic bootstrapping”, it has been argued that structural guidance in word learning, as just discussed, becomes crucial in the case of acquiring the meanings of verbs. This is because these words – as opposed to nouns that label object categories – are too abstract to be efficiently induced from extralinguistic evidence alone (Gleitman & Gleitman, 1995; Snedeker & Gleitman, 2000). Of course, difficulties in inducing word-to-world patterns arise for even the most homely and concrete nominal vocabularies. One problem pervasive over the lexicon as a whole is the “stimulus-free” property of language use. One can talk of zebras outside of zoos or savannahs and forebear from zebra-talk in the presence of zebras, as Chomsky (1959) famously urged in response to the most simplistic version of a word learning theory. The problem of detecting a word’s meaning from observing the circumstances of its use arises even more poignantly within empiricist speculative theory that holds that there are no principled constraints (from human nature) on what a word meaning could be (cf. Quine, 1960). On either of these otherwise quite disparate perspectives, all words should be hard to learn because even if the mind is rich and restrictive in its categorial furnishings, the world itself does not come spliced into readily observable instances of such categories.

Several authors have pointed out that these problems are greatly exacerbated in the case of early verb learning as compared to early noun learning. Gentner (1978) was the first to discuss the contrast between nouns and verbs in the learning context in her analysis of why verbs tend to appear in child vocabularies later than nouns, despite wide variation both in languages learned and in the input corpora provided by caretakers (see also Gentner, 1982; Gentner & Boroditsky, 2001). In this work, it is purported to be the relational nature of verb meaning that serves as the central cause of this difference in the acquisition functions for the two classes.¹ (See also Gillette et al. (1999) and Snedeker and Gleitman (2000) who demonstrate a difference in concreteness or imageability in how these classes are used in speech by caretakers of young children.)

4. An experimental review

As advertised in the beginning, our question most broadly put is determining the senses

¹ From this perspective, the hardest verbs to learn would be those that express no lexical content at all, e.g. copulas. See Becker (2000, 2002) for discussion.

in which word learning is driven by observation and the senses in which it is driven by properties inside the learner. We address this question through issues associated with verb learning because the problems with word-to-world mapping are more severe and pervasive in this aspect of lexical learning than for object-labeling nouns. To overcome the inherent obstacles to verb learning, Landau and Gleitman (1985) proposed the Syntactic Bootstrapping Hypothesis. The idea behind syntactic bootstrapping is that the learner can take advantage of grammatical constraints on the relation between verb meaning and verb syntax to narrow the space of hypotheses about a given verb's meaning. When the child hears a verb used in several syntactic structures, he can use his knowledge about how verbs project into the syntax universally in order to pinpoint the intended meaning; that is, to select a preferred interpretation from among the several possibilities made viable by observation of the extralinguistic contexts of use.

It is well documented that toddlers are able to make such inferences about verb meaning on the basis of the structures that verbs appear in (Fisher, 1996; Fisher et al., 1994; Gleitman, 1990; Landau & Gleitman, 1985; Naigles, 1990; Naigles, Gleitman, & Gleitman, 1993; Naigles & Kako, 1993, *inter alia*). What remains to be determined is how learners of specific languages gain the knowledge that drives these inferences about the syntax–semantics interface. It could be that no learning is required for this feature of the learning machinery; rather (some useful subset of) these inferences reflect properties of the syntax–semantics mapping that are a direct consequence of the way meaning maps onto form universally (Lidz, 1998a). At the other extreme, all of these interface relations may be highly variable cross-linguistically, in which case they are deduced from observation, as proposed, for example, by Goldberg (1999) and Tomasello (2000).

On both of these views, a child who knows some aspect of a verb's meaning can anticipate some of the structures that the verb might be used in (as in, e.g. Pinker, 1984). These theories differ, however, in the origins of this ability. On the former, universalist, view, these inferences are supported by the grammatical architecture necessarily true of human languages. One argument for this “unlearned” position is that linguistically isolated deaf children create a rudimentary signing system exhibiting much the same argument structure/syntactic structure relations as do known languages. For example, these children's utterances tend to associate one noun with the verbs *sleep* and *swim*, two nouns with *hit*, and so forth (Feldman, Goldin-Meadow, & Gleitman, 1978; Goldin-Meadow & Mylander, 1984). Since these children manifestly did not acquire the syntax–semantics interface from the input (there was no relevant input), the finding suggests a naturalness to the particular correlations widely found in the received languages: noun phrase number lines up as simply as possible with argument number (cf. the Theta-criterion of Chomsky, 1981; for discussion in the learning context, see Jackendoff, 1978; Fisher, 1996).

In contrast, according to the emergentist view, the syntax–semantics correlations are caused and supported by the observations that the child has accumulated regarding the use of verbs with similar meanings. And there is preliminary evidence for this view too. For example, children taught a verb in one syntactic context are reluctant to use it in other syntactic contexts that would be predicted by the universalists on the basis of meaning similarity; this tends to suggest that the child is learning form–meaning correlations verb by verb and structure by structure (Tomasello, 1992, 2000).

We propose to tease apart these two approaches by examining a case in which universal

properties of the syntax–semantics mapping are pitted against language particular properties. If the child’s knowledge is derived solely from observation, then we should see the effects of language particular properties, possibly at the expense of universal properties. On the other hand, if the child’s knowledge reflects an underlying grammatical system, then we should see the effects of universal properties at the expense of the language particular properties.

5. Syntactic bootstrapping and causativity

One construction that has been examined extensively from the perspective of syntactic bootstrapping is the *causative*, i.e. sentences with verbs whose meaning includes some notion of causation. The verb *kill*, for example, means something like ‘cause to die’ (*pace* Fodor) and *bring* means something like ‘cause to come’. A number of experimenters have found that 2- to 4-year-old English-speaking children will interpret transitive sentences as causative and intransitive sentences as noncausative, *ceteris paribus*, even with nonsense verbs (Fisher, 1996) or with verbs that do not occur grammatically in these frames (Naigles, Fowler, & Helm, 1992; Naigles et al., 1993). Thus, little children hearing *Noah comes the elephant to the ark* interpret this as meaning that Noah brings the elephant to the ark, in other words, that Noah causes the elephant to come to the ark. These findings have also been extended to French (Naigles & Lehrer, 2000).

Both the “universalist” and “emergentist” positions can explain the causative interpretation of novel transitive sentences. The universalist is free to say that the “causer” of the event requires its own noun phrase slot in the structure, accounting for why we say *The door opens* but, when expressing the agent of this event, we say *John opens the door*, and for why the child tends to induce a causative meaning for *John pilks the cow*. Transitivity is a strong cue for causativity.² The emergentist theorist is not embarrassed by these same facts, however. He or she is free to claim that because such a correlation has previously been observed in the exposure language for such verbs as *open*, *sink*, *melt*, and the like (which share causativity as part of their meaning), one can generalize and decide that a new transitive verb is likely to render causativity as part of its interpretation.

The two positions diverge, however, in their predictions about languages in which transitivity is not the best predictor of causativity. In such a language, the universalist theory predicts that young children will use transitivity as the primary indicator of causativity even so, for the argument number/noun phrase number relation is part of the presuppositional structure that learners bring into the verb learning task.³ They point to little children saying *Daddy giggled me* and *I filled milk into the glass* as evidence that the child has a pretty canny notion about which forms can encode which meanings (Bowerman, 1982; Braine, Brody, Fisch, Weisberger, & Blum, 1990; Pinker, 1989). On the other

² We should note that the inductions here are not fully warranted. There are plenty of noncausative transitive verbs. For example, *Max sees Chris* does not mean that Max causes Chris to see. What is true of English and other languages is that verbs with causative meaning have a minimum of two arguments and so it is a good bet, though not a sure thing, that transitivity expresses causation.

³ See the papers in Comrie and Polinsky (1993) for discussion of the universal connection between transitivity and causativity. Also see Aissen (1974), Kayne (1975), Rizzi (1982), and Burzio (1986) for syntactic diagnostics linking the syntax of causatives with that of simple transitives in various languages.

hand, the emergentist theory predicts that the most reliable cue (whatever this is) will be the first to be associated with causativity. If the language is English, argument number as a reflection of causativity will emerge from the input data (on this story, the meaning of the verb itself is acquired solely from noting its extralinguistic contingencies).

6. Kannada

The language that we will compare to English is Kannada, a Dravidian language spoken by approximately 40 million people in southwestern India. For this language, the most reliable cue for causativity is a causative verbal affix. While there are some inherently causative verbs that express causation without the causative morpheme, the causative morpheme never occurs unless causative meaning is intended (Lidz, 1998b, in press; Sridhar, 1990). Transitivity, however, freely occurs with or without causative meaning and with or without causative morphology. Consider the following.

- (1) a. kudure eer-utt-ade
horse rise-npst-3sn
'The horse rises.'
- b. * moSale kudure-yannu eer-utt-ade
alligator horse-acc rise-npst-3sn
'The alligator raises the horse.'
- c. moSale kudure-yannu eer-is-utt-ade
alligator horse-acc rise-caus-npst-3sn
'The alligator raises the horse.'

In (1), we see that the verb *eeru* ('rise') can be used intransitively (1a) and that to transitivize it, the causative morpheme *-isu* is required (1b vs. 1c). This contrasts with a verb like *ettu* ('lift'), which cannot be used intransitively (2a), can be used transitively (2b) and has a triadic (i.e. three-argument) meaning when marked with the causative morpheme (2c).

- (2) a. * kudure ett-utt-ade
horse lift-npst-3sn
'The horse lifts.'
- b. moSale kudure-yannu ett-utt-ade
alligator horse-acc lift-npst-3sn
'The alligator lifts the horse.'
- c. moSale kudure-yannu ett-is-utt-ade
alligator horse-acc lift-caus-npst-3sn
'The alligator makes something lift the horse.'
* 'The alligator lifts the horse.'

In general, the causative morpheme can be added to any verb, adding a causing event to the event denoted by the verb. As in all languages (including English), there are many transitive

verbs in Kannada which do not denote causative events. For example, (3) does not mean that alligator makes the horse see.

- (3) moSale kudure-yannu nooD-utt-ade
 alligator horse-acc see-npst-3sn
 ‘The alligator sees the horse.’

While it is true that causative meaning is always expressed with transitive structures, the child making inferences from structure to meaning cannot be sure that transitivity marks causativity. On the other hand, a child learning Kannada can make a valid inference from causative morphology to causative meaning. Whenever there is a causative morpheme in the sentence, a causative meaning is expressed. Thus, in Kannada, as in English, transitivity is a probabilistic cue to causativity; however, the causative morpheme is a better cue to causativity than is transitivity.

These facts give us a way to examine the origins of syntactic bootstrapping effects and, in turn, to address one of the fundamental questions facing language theorists: what is the child’s contribution to language learning? As we have noted, two positions have emerged in the present context. On the one view, learning could be driven by the very way that the child encodes and represents the input. Under this interpretation, the input is used as a guide, or calibration device, through a largely predetermined hypothesis space. On the other view, learning could be achieved by taking careful note of those properties that dominate in the input. These perspectives lead to different predictions for Kannada and English verb learning in the relevant regards.⁴

A learning mechanism that takes advantage of universal principles of mapping between meaning and syntax will expect that transitive syntax corresponds to causative meaning a large proportion of the time simply as a consequence of the principles of lexical projection. This theory therefore leads us to expect Kannada-learning children to show a bias towards interpreting transitive syntax as expressing causative meaning, just as the literature reports for English-learning children. On this view, we might expect to find a stage in which children would ignore in large measure the role of the causative morpheme in expressing causative meaning, for this is a special feature of Kannada (an outcome of learning, to be sure). That is, the feature of the input which best predicts causative meaning would take a back seat to the child’s internally generated expectations about what languages are like.

The alternative mechanism, i.e. the one that builds syntax–semantics correspondences by observation of input features, will learn that the best predictor of causative meaning in the Kannada case is causative morphology. This theory therefore leads us to expect Kannada-learning children to show a bias towards interpreting causative morphology as causative meaning, independent of syntactic transitivity. This mechanism is predicated on the idea

⁴ It is important to observe that although we are pitting the morphological cue against the syntactic cue in our experimentation, it is clearly not the case that these expressions of causativity are in any kind of grammatical competition (in the sense of the Elsewhere Condition (Kiparsky, 1973) or Blocking Principle (Aronoff, 1976; Williams, 1997)) in the linguistic system of Kannada. Where there is competition, it is between lexical causativity and morphological causativity. Here we see that morphological causativity is the general case which is sometimes blocked by the more specific lexical causative. See Lidz (1998b) for details.

that the child has no internally generated preconceptions about language structure and so will learn just what can be most straightforwardly extracted from the input.

6.1. *Some morphosyntactic and semantic details of causativity in Kannada*

Before continuing on to the experimental section of the paper we will spell out some details of the grammar of causation generally and in Kannada. The logic of the comparison between transitivity and causative morphology discussed above requires that the kind of causation (semantically speaking) expressed by morphological causatives in Kannada is equivalent to the kind of causation expressed by transitivity in English. So, in this section we establish the syntactic and semantic parallels between causativity expressed through transitivity and causativity expressed morphologically.

In examining the nature of causation, it is important to distinguish the morphosyntactic expression of causation from the semantic varieties of causation. Typologically, languages express causative events in three morphosyntactic ways (Comrie, 1976, 1985; Comrie & Polinsky, 1993; Shibatani, 1976). Periphrastic causatives, such as the English (4), use an independent lexical item to express the causing event:

(4) I made the ice melt.

Morphological causatives, such as the Japanese (5) (Harley, 1995), use an affix within the verbal complex to encode the causing event:

(5) Doroboo-ga Yakko-o waraw-ase-ta
 thief-NOM Yakko-ACC laugh-CAUS-PST
 ‘A thief made Yakko laugh.’

Finally, lexical causatives, such as the English (6b), express the causative event simply by adding an additional syntactic argument to a noncausative verb:

(6) a. the ice melted
 b. I melted the ice

Kannada has all three types of causativity:

(7) a. intransitive
 barf-u karg-i-tu
 ice-NOM melt-PST-3SN
 ‘The ice melted.’

b. periphrastic causative
 naanu barf-annu kargu-vante maaD-id-e
 I ice-acc melt-pred make-pst-1s
 ‘I made the ice melt.’

c. morphological causative
 naanu barf-annu karg-is-id-e
 I ice-ACC melt-CAUS-PST-1S
 ‘I melted the ice.’

- (8) a. intransitive
 baagilu much-i-tu
 door close-pst-3sn
 ‘The door closed.’
- b. periphrastic causative
 naanu baagil-annu muchi-vante maaD-id-e
 I door-acc close-pred made-pst-1s
 ‘I made the door close.’
- c. lexical causative
 naanu baagil-annu much-id-e
 I door-acc close-pst-1s
 ‘I closed the door.’

There is only a small set of verbs in Kannada that allow causativity to be expressed lexically. The remainder require the causative morpheme.

Semantically, we can distinguish direct and indirect causation (Shibatani, 1976). The distinction can be seen clearly in English in the following examples:

- (9) a. Chris made the vase fall
- b. Chris dropped the vase

While in both (9a) and (9b), the agent of the event, Chris, is responsible for the vase falling, the nature of this responsibility differs in the two cases. In (9b), we assert that the agent is directly responsible for the vase falling by letting go of it. In (9a), however, the vase falls not because of a direct action of the agent on the vase, but more indirectly, for example if Chris shook the pedestal that the vase was sitting on.

How these two semantic types of causation map onto the morphosyntactic expression causativity depends upon the range of morphosyntactic options found in the language. In Kannada, direct causation is expressed by lexical and morphological causatives whereas indirect causation is expressed by periphrastic causatives.⁵ In a situation in which I closed the door by pushing it shut, (8c) is more natural than (8b), whereas in a situation in which I made the door close indirectly, say, by removing the door-stopper on a windy day, (8b) is more natural than (8c). Similarly, if I melt the ice by putting it on a flame then (7c) is more

⁵ This characterization is not quite complete. If a verb that is already causative is morphologically causativized, then the morphological causative expresses indirect causation:

- (i) hari naan-inda baagilannu terey-is-id-a
 Hari I-instr door-acc open-caus-pst-3sm
 ‘Hari made me open the door.’
- (ii) hari nann-inda barf-annu karg-is-is-id-a
 hari I-instr ice-acc melt-caus-caus-pst-3sm
 ‘Hari made me melt the ice.’

See Miyagawa (1998) for similar facts in Japanese.

natural than (7b), whereas if I make the ice melt by turning off the freezer, then (7b) is more natural than (7c). Thus, the lexical and morphological causatives express the same meaning; which is used is determined by the particular verb chosen.

We can see further that the syntactic position of the causee is equivalent in lexical and morphological causatives but not in periphrastic causatives. The causee in a periphrastic causative construction can control into an adjunct clause whereas the causee in the lexical and morphological causatives cannot:

- (10) a. naanu jileebi tinn-utt-aa magu-vannu ett-utt-eene
 I jileebi eat-npst-while child-acc lift-npst-1s
 ‘I will lift the child while eating jileebi.’
 = while I eat jileebi
 ≠ while the child eats jileebi
- b. naanu jileebi tinn-utt-aa magu-vannu eer-is-utt-eene
 I jileebi eat-npst-while child-acc rise-caus-npst-1s
 ‘I will raise the child while eating jileebi.’
 = while I eat jileebi
 ≠ while the child eats jileebi
- c. naanu jileebi tinn-utt-aa magu-vannu eeru-vante maaD-utt-eene
 I jileebi eat-npst-while child-acc rise-pred make-npst-1s
 ‘I will make the child rise while eating jileebi.’
 =while I eat jileebi, OR
 = while the child eats jileebi

Thus, the data in (10) demonstrate that the syntax of transitivity (or lexical causativity) does not differ from the syntax of morphological causativity (see Lidz, 1998b, in press for additional arguments).

An additional assumption that our comparison between morphological causativity and transitivity makes is that the morphological cue is easily detectable by children learning Kannada. If the morphological cue were infrequent or hard to detect, then the emergentist position might not predict that children would make use of it. Fortunately, there are several facts that make it seem reasonable to suppose that learners can notice this morpheme in the input. First, the causative morpheme is the fifteenth most frequent bound morpheme in the language, ahead of such morphemes as plural, dative case, and 3rd person feminine agreement (Ranganatha, 1982).⁶ This suggests that the morpheme occurs often enough for children to notice it. Second, this morpheme has only one allomorph, [is]. Both segments are always present and neither undergoes any morphophonological alternation in context. This also suggests that the morpheme will be easy for learners to detect since its form is invariant across contexts. Third, there is no other morpheme in Kannada which surfaces as [is]. This is important because it means that the learner will have no opportunity to misanalyze other morphemes as the causative, potentially leading to a failure to

⁶ Devaki (1991) demonstrates that 3-year-old native speakers of Kannada already have productive command of the full range of verbal inflectional affixes and the nominal case system. Devaki did not test causatives, however.

determine its grammatical function. Together, these facts make it safe to assume that the causative morpheme is a well chosen candidate for a purely distributional learner to use in the assignment of causative meaning to grammatical form.⁷

7. Experiment 1

The experiment now reported attempts an adjudication of the two approaches to syntactic bootstrapping effects by asking how children exploit syntactic information in a language in which the universal mapping between meaning and syntax might be overshadowed by language particular factors. Methodologically, we build upon the findings of Naigles et al. (1992, 1993) about child responses to old verbs in new syntactic environments. This work shows that children will extend the meaning of a verb they already know on the basis of its syntactic environment, an effect known as “frame compliance”. Here we add morphological information into the equation, where it might appear to be more informative than syntax, to see whether the children will use the morphology or the syntax (or more catholically, both) as the information source upon which to build their generalizations.

7.1. Design and procedure

Following the procedure of Naigles et al. (1993), we asked young children to act out utterances using a set of toy animals as the vehicle. The stimulus set was constructed from 24 verbs, 12 transitive and 12 intransitive. Each verb was placed in four syntactic environments, crossing argument number by morphological form. That is, each verb was used in both 1-argument and 2-argument syntactic frames both with and without causative morphology, giving rise to a 2 (lexical valency: transitive vs. intransitive) \times 2

⁷ An anonymous reviewer suggests that our characterization of the emergentist expectations, based on cue validity, might be too simplistic. If the learning device were taking advantage of the mutual information between the causative morpheme and causative interpretation on the one hand, and argument number and causative interpretation on the other, then it is possible that even a purely distributional learner would favor argument number over the morphological cue for causative interpretation. In particular, if it were the case that $P(\text{causality} | > 1 \text{ NP})$ is relatively high (which may or may not be true) and $P(> 1 \text{ NP} | \text{causality})$ is also high (which seems likely) and if $P(\text{causative morpheme} | \text{causality})$ is relatively low (which also may or may not be true) while $P(\text{causality} | \text{morpheme}) = 1$ (as we have been assuming), then it might turn out that a distributional learner would learn that argument number is a reliable indicator of causativity since the mutual predictability of $> 1 \text{ NP}$ and causality would be higher than the mutual predictability of the morpheme and causality. If this turned out to be true, then our comparison would not be justified since both the emergentist and the universalist would make the same prediction regarding children’s early knowledge of causativity. We agree that, in principle, this is a possible outcome, though whether it is actually true depends on details of distribution that are not currently available. That is, evaluation of this possibility would require analysis of a large-scale morphologically and syntactically parsed corpus of Kannada. Unfortunately, such a corpus does not currently exist, though building such a corpus is clearly a priority, and so we leave evaluation of this possibility for future work. Of course, if it turned out that the more complex statistical calculation based on mutual information made the same prediction as the universalist perspective described above, that would only increase the need for constraints on the learner. As we admit a broader range of statistics that the learner might use in extracting information from the input, we increase the need for constraints on the learner. As the hypothesis space gets larger, language acquisition gets more difficult, not less, since the learner has more hypotheses to discount on the way to building a grammar.

(argument number: 2-argument vs. 1-argument) \times 2 (morphology: bare vs. causative) design. In order to avoid giving each child every verb in every environment, the verbs were divided into four groups, each containing three transitive and three intransitive verbs. The subjects were then divided into four groups, differing by which set of verbs occurred in which morphosyntactic frame in their stimulus set. For example, subjects in group 1 heard the verbs from group A in the bare/1-argument frame, the verbs from group B in the causative/1-argument frame, the verbs from group C in the bare/2-argument frame and the verbs from group D in the causative/2-argument frame. The other three subject groups were created by permuting the set of verbs that occurred in each frame. In addition to the test stimuli, each subject was asked to act out four practice items using nontest verbs (*swim*, *dance*, *climb* and *run*) in order to familiarize them with the task. Thus, each subject was asked to act out 28 utterances, four practices plus one for each verb in the set of test verbs. Prior to beginning, each subject was asked to name the animals. At the end of each trial, the subjects were praised and given encouragement, independent of the actions they performed. The subjects were all given stickers for participating.

The pattern of grammaticality of the test items is as follows:

		Intransitive verb	Transitive verb ⁸
<i>Bare 1-arg</i>	NP V	Yes	<i>No</i>
<i>Caus 1-arg</i>	NP V _{caus}	<i>No</i>	<i>No</i>
<i>Bare 2-arg</i>	NP NP _{acc} V	<i>No</i>	Yes
<i>Caus 2-arg</i>	NP NP _{acc} V _{caus}	Yes	<i>No</i>

The list of verbs and the list of verb groups is given in Appendix A. The full set of test stimuli is given in Appendix B.

7.2. Subjects

The subjects were 24 children between the ages of 3:2 and 3:10 (mean age = 3 : 6), tested individually at either Pushkarini Preschool or Swami Vivekananda Preschool in Mysore, India. Subjects of this age were chosen because children at this age were shown to be likely to be frame compliant in previous studies on English (Naigles et al., 1992, 1993). Subjects were assigned to groups randomly. Three subjects were eliminated from the study because they performed the same action on every test item. The test items for these subjects were then given to three new subjects.

⁸ The cells marked 'no' are marked as ungrammatical under an interpretation in which only the NPs mentioned are considered participants in the event. That is, Kannada does allow arguments to be dropped in restricted discourse contexts. So, for example, a transitive verb in the bare/1-argument context could be interpreted as *NP Ved something*, where the value of *something* is determined by context. Because the sentences were presented out of context, the discourse conditions licensing null-argument interpretations were not satisfied and so such sentences are marked as ungrammatical.

7.3. Coding

The coding procedure followed the procedure developed by Naigles et al. (1993). Coders were given a list of actions and were told to indicate which of these actions was performed by the child. These actions were then divided into two groups. One group of actions was taken as a signal to a causative act-out. The other group was taken to signal a noncausative act-out. So, each of the child's responses was coded as either causative or noncausative. Because we are interested in comparing the effects of transitivity as the expression of lexical causativity/direct causation with the effects of the causative morpheme as the expression of direct causation, only act-outs which displayed direct causation were counted as causative. Act-outs which reflected indirect causation were not coded as causative. The instructions given to the coder are included in Appendix C. In addition, half of the responses for four children were coded by a second coder. Agreement between the two coders was 94.6%.

7.4. Results

The proportion of causative act-outs were entered into an analysis of variance (ANOVA) with three factors: argument number (1 vs. 2), morphology (bare vs. causative) and valency (intransitive vs. transitive). The universalist position predicts a main effect of argument number, with 2-argument structures yielding causative act-outs independent of verb valency or morphology; the emergentist position predicts a main effect of morphology, with morphologically causative verbs yielding causative act-outs independent of verb valency or argument number. We found a main effect of argument number ($F(1, 176) = 188.29$, $P < 0.0001$) and no effect of morphology ($F(1, 176) = 0.309$, $P > 0.844$) or valency ($F(1, 176) = 2.77$, $P > 0.097$) and no significant interactions. That is, verbs in 2-argument structures were acted out causatively reliably more often than verbs in 1-argument structures, independent of either the verb's inherent valency or morphological form, indicating that children rely on the syntactic cue to causativity in favor of the morphological cue. The data are given in Fig. 1.

7.5. Discussion

These results argue against the hypothesis that argument structure patterns are learned from the input and support the hypothesis that interpretive effects of syntactic structure arise from universal mappings between lexical meaning and syntactic structures. For these children, only the number of arguments determined whether children would produce a causative or noncausative act-out. Two-argument sentences were acted out causatively and 1-argument sentences were acted out noncausatively. Morphological form appeared to have no effect on their responses, despite the fact that morphological form is the best predictor of causative meaning in the input that children receive.

8. Experiment 2: Kannada adults

In order to ensure that the results of Experiment 1 are informative about language

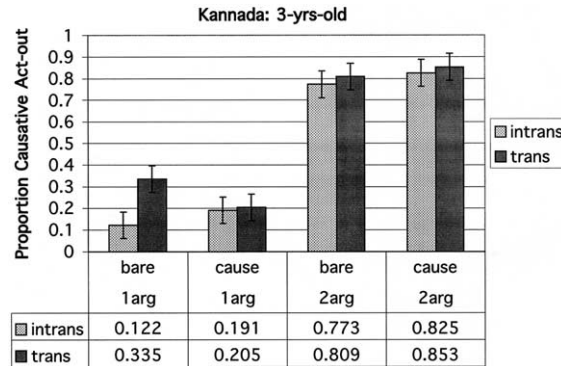


Fig. 1. Kannada 3-year olds: proportion of causative act-outs.

learning and not about differences between Kannada and English, we tested Kannada-speaking adults using the same stimuli. In previous studies using an act-out task to test the effects of syntax on verb learning, adults failed to show effects of syntactic structure on verb interpretation (Naigles et al., 1992, 1993). That is, adults typically treated the ungrammatical test items as errors in grammaticality and relied instead on the meaning of the verb to inform their responses: in other words, adults are “verb compliant”, compliant with the meaning they have previously assigned to the verb, whereas children are “frame compliant”, in revising the meaning of the old verb in light of the new syntactic circumstances.⁹ Thus, while for adults we still expect to see some effect of transitivity on causative interpretation (this being a real, though nondeterministic, correlate), we also expect to find some effect of the verb’s inherent valency and some effect of causative morphology (the strongest cue in Kannada structure). Since valency and morphology, in addition to argument number, contribute to the likelihood of causative interpretation in the language, we expect to see these effects in our experiments with adults.

8.1. Design

The design was the same as in Experiment 1.

8.2. Subjects

The subjects were 20 adults who were students or employees of Mysore University in Mysore, India. All subjects were tested in a quiet room in the Mysore University Guest House. Subjects were not compensated for their participation.

⁹ The transition from frame compliance to verb compliance in English seems to be connected to lexical frequency with more frequent verbs showing verb compliance effects earlier than less frequent verbs (Naigles et al., 1992).

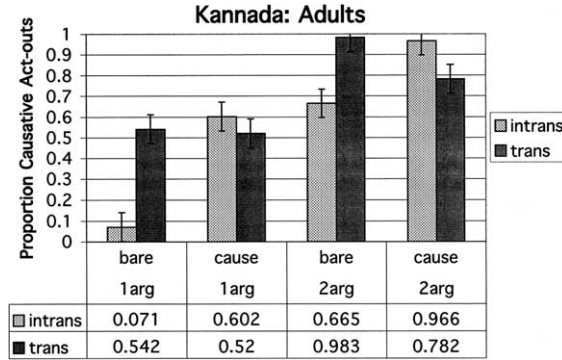


Fig. 2. Kannada adults: proportion of causative act-outs.

8.3. Results

An ANOVA performed on the adult data reflects the full range of factors contributing to the interpretation of causation. We find main effects of argument number ($F(1, 152) = 67.66, P < 0.0001$), morphology ($F(1, 152) = 9.04, P < 0.003$) and valency ($F(1, 152) = 6.68, P < 0.01$). We also find a significant interaction between morphology and valency ($F(1, 152) = 27.21, P < 0.0001$) and a significant interaction between morphology and argument number ($F(1, 152) = 4.09, P < 0.04$). The data are given in Fig. 2.

In interpreting the adult data, it is important to keep in mind that only three sentence types are grammatical on an interpretation in which all of the arguments of the verb are syntactically present: the 1-argument use of bare intransitive verbs, as in (11a); the 2-argument use of causative-marked intransitive verbs, as in (11b); and the 2-argument use of bare transitive verbs, as in (11c).

- (11) a. simha hoog-utt-ade
lion go-NPST-3SN
'The lion goes.'
- b. huli jinkey-annu hoog-is-utt-ade
tiger deer-ACC go-CAUS-NPST-3SN
'the tiger makes the deer go.'
- c. timingala chithey-annu ett-utt-ade
whale butterfly-ACC lift-NPST-3SN
'the whale lifts the butterfly.'

All other permutations are ungrammatical. For sentences like those in (11a), we would expect adult subjects to produce virtually all noncausative act-outs, since there are no cues for causativity in the sentence. This expectation is met, as subjects produced only 7% causative act-outs for this kind of sentence. For sentences like (11b) and (11c), we

would expect our adult subjects to produce virtually all causative act-outs, since in these sentences there are appropriate lexical, morphological and syntactic cues to causativity. These expectations are also met, as subjects produced 96% and 98% causative act-outs for these sentence types, respectively. This is important because it indicates that when stimuli are grammatical, adults can be counted on to act-out the relevant aspect of meaning.

For the remainder of the stimuli, we do not expect such clear effects of the various cues to causativity because in these stimuli, we have the additional factor that the sentences are either ungrammatical or infelicitous. For those sentences with one argument more than would be predicted by either the morphology or the verb, as in the case of intransitive verbs used in 2-argument structures, we expected subjects' responses to be sensitive to some extent to each cue, depending on whether they attribute the ungrammaticality to the failure to produce the appropriate morphology or on the insertion of an extra argument. Hence, we expect some causative act-outs, showing a reliance on the syntax, and some noncausative act-outs, showing a reliance on the verb's valency. This is what we found; subjects produced some degree of causative responses, but not as much as with grammatical causative sentences. For those sentences with one argument less than would be predicted by either the morphology or the verb, as in the case of morphologically marked intransitive verbs in 1-argument contexts or morphologically marked transitive verbs in 2-argument contexts, again we expect subject responses to be sensitive to some extent to each cue. Either we expect our subjects to rely on an interpretive strategy that attributes an error to the speaker and hence relies on the meaning of the verb to guide their act-outs (as in Naigles et al., 1993), or we expect them to suppose that there was an argument missing from the sentence and to supply that extra argument from the array of toys before them. Thus, for such sentences we expected some degree of causative act-outs, but not as much as would be expected with the grammatically causative sentences.

Of particular interest in this light are the morphologically causative uses of transitive verbs in 2-argument structures. In these sentences there are three "cues" to causativity (the verb, the morphology and the syntax) and so we might expect subjects to be at ceiling in giving causative act-outs. However, these cues are incompatible in these sentences and so we expect some variability in how people resolve this incompatibility, with some providing act-outs reflecting direct causation (in essence ignoring the morphology), and others providing act-outs reflecting indirect causation (by providing an additional participant for the event). Indeed, this is what we found. That is, the cues to causativity each make some contribution to the adults' causative interpretations and when these are in conflict with each other, subjects rely differentially on one cue or the other.

9. Discussion

9.1. Interpreting the experimental findings

The experiments just presented are replicated in Kannada effects already in the literature

for several other languages concerning the interpretation of old verbs in new frames. As in these prior works, we showed that children are heavily influenced in their interpretations by the new structures in which the old verbs were presented: children are capable of using structure as well as, or even instead of, nonlinguistic circumstance to derive verb interpretations. And, just as in prior studies, these old verbs in new structures were found to be less semantically mutable for adults than for children.

However, our ambition in these experiments went beyond extending such findings to a non-Indoeuropean language. The special interest of the Kannada–English comparison was that cues to causative meaning were differentially reliable in the two languages. For both languages, argument number is a probabilistic cue to causativity (e.g. true of *kill*, *melt* and *open*; but false of *see*, *touch*, and *hear*). But for Kannada, there is a language-specific morphological cue that is determinative. The morpheme *-isu* just means ‘cause’. In its presence, a verb is causative, period. Compare this to the case of English which has sporadically used causative suffixes such as *-ize* as in *magnetize*, which is limited in the stems that it can attach to (**waterize* or **houseize* are hopeless and even *colorize* is barbaric), and with adrift or submerged root interpretation in many cases where it does appear (e.g. *characterize*, *homogenize*, *agonize*).¹⁰

From these facts, straightforwardly different effects were predicted under the universalist and emergentist perspectives. Universalists would note a fact to which we alluded in introductory remarks: causal agent is an independent argument in most formulations of the logic of predicates. As such, the entity playing the causal role in a predication shows up as an independent noun phrase in the structure of the clause. In linguistic terms, this is a consequence of the theta criterion, an interface principle requiring semantic arguments to be syntactically realized (Baker, 1985; Chomsky, 1981; Hale & Keyser, 1993; Jackendoff, 1990). In psychological terms, the simplest encoding of predicate–argument logic is one in which each entity “out there” in the world (or at least in our mental representation of the world) is matched by a linguistic entity in the clause (e.g. Fisher, 1996; Fisher et al., 1994; Miller & Gildea, 1987). The beginning learner would seize upon such expected correlations as the potent structural cues to verb interpretation. Such effects would be quite robust to the actual reliability of this cue in the exposure language.

The emergentist expectation would be quite different. From this perspective, the early verb meanings are gleaned, one by one, from extralinguistic evidence operating alone. Once verb after verb after verb is acquired then, and only then, does the learner generalize across them. If so, then the morphological cue would be the first to be used by Kannada-speaking children just because it is a more reliable aspect of the input than argument number, despite the fact that the morphological cue is by no means universal.¹¹

The findings we have reported strongly support the universalist view. In Experiment 1, to decide on the interpretation of old verbs in new syntactic environments, the young

¹⁰ See Rosenberg (1995) and Plag (1999) for discussion of the systematic semantic properties of *-ize* in cases where it can be used.

¹¹ Note that English learners acquire derivational morphological cues (e.g. the one in *agonize*, the one in *redde*n and the one in *clarify*) late and variably (Freyd & Baron, 1982). This fact does not distinguish between the hypotheses at issue because either within-language variability or cross-language variability (or both) would disfavor early acquisition of this feature of English.

children ignored the determinate morphology and were influenced by argument number alone (Fig. 1), just like English children for whom a morphological cue is unavailable or highly unreliable. In other words, biases concerning which cues are prepotent to use in learning seem to withstand strong differences in the reliability of these cues in the exposure language. In this sense, the child's generalizations appear to be more "learner-driven" than "input-driven".

One might object to this conclusion by noting that the children we studied were 3 years old, surely not the youngest verb learners. On these grounds, one might offer that the days of verb by verb learning as discussed in Tomasello (1992, 2000) are long gone by. However, that interpretation runs counter to the findings in this kind of experiment as conducted in several languages by Naigles and her collaborators, which have always found the frame compliance effect to maintain its power over at least the first 4–5 years of life, though diminishing rapidly thereafter. As we showed in Experiment 2, Kannada adults – but not Kannada 3-year-olds – have moved into a stance that is much more eclectic and responsive to the particulars of the exposure language. Though their interpretations of old verbs in new structural environments do take account of argument number, these adults have also become highly responsive to the pervasive causative morpheme of Kannada as well as to the idiosyncratic properties of particular verbs. We conclude that early in life certain universal cues at the syntax–semantics interface are prepotent for acquisition of the verb lexicon. The adult, however, has adjusted such procedures to take into account various syntax–semantics relations that he or she has derived from the observation of specifics of the exposure language, a classic case of what Slobin (2000) has dubbed "typological bootstrapping".

9.2. *The broader context*

Beyond the details of lexical acquisition, our results figure into a debate whose participants over the years have included Meno vs. Socrates, Locke vs. Leibniz and Skinner vs. Chomsky. This debate revolves around the contribution of the learner in knowledge acquisition. In the current context of language learning, the debaters often pit general purpose statistical learning against domain-specific constraints on representation. It is a very curious fact that some recent commentators have adopted the radical idea that one could man the barricades unflinchingly on one side of this debate or the other for language learning. Of course one's language is learned. And of course it cannot be just anything.

It is revealing that the proponents of these two general approaches rarely study the same properties of the child. The finding that children are astonishing statistical sponges comes largely from studies focusing on, e.g. the discovery of word boundaries (Saffran, Newport, & Aslin, 1996), phonotactic constraints (Brent & Cartwright, 1996), and the assignment of words to grammatical categories (Mintz, Newport, & Bever, 1995; cf. Brill & Marcus, 1992). To our knowledge, none of the authors generating this literature adduce these findings to suggest that human infants learn a language as open-mindedly as they learn to knit or name Pokemon characters. Quite the contrary, all of them assume a search space for the functions studied that is limited by nature, both in terms of the categorial space and the kinds of statistical analyses that the infant is prepared to perform (Newport & Aslin, 2000). For example, even the earliest studies of infant speech perception (Eimas, Sique-

land, Jusczyk, & Vigorito, 1971) emphasized an innately given perceptual discrimination space which organizes and constrains the child's search space for phoneme boundaries in the exposure language (Lieberman, Cooper, Shankweiler, & Studdert-Kennedy, 1967; Werker, 1995). Conversely, work in support of the idea that language learners come equipped with representational assumptions typically focuses on abstract areas of syntax that are less likely to be learned from the input without some prior representational commitments on the part of the learner (Chomsky, 1975; Crain, 1991; Crain & Thornton, 1998; Hornstein & Lightfoot, 1982).

In sum, and as most commentators acknowledge, the serious question in language learning is not “whether” distributional evidence can be used or “whether” there are unlearned or natural constraints on linguistic representation, but rather what are the domains in which each of these kinds of mechanism provides the best solution and how can these mechanisms work in tandem in the process of language acquisition.

In the current paper, we have picked up this debate in an area in which either outcome might be possible, or in which the child learner might find some middle ground. The mapping between syntactic structure and verb meaning might be pulled out of distributional analysis or it might be a consequence of grammatical organization. There is no question that relevant information is present in some highly encoded form in the input (Fisher, Gleitman, & Gleitman, 1991; Li, Burgess, & Lund, 2000). The experiments we reported suggest that the learners are biased in how they will dive into this complex database of input speech so as to extract the verb meanings. Noun phrase number is a privileged source of information as to the semantic structure of predicates.

9.3. *Final thoughts*

Another way to understand the debate just joined is to ask how the input database got to be the way it is in language after language. Several investigations have documented the presence of the noun phrase number cue to argument structure in languages where the result might have been anticipated to be different, e.g. English (Lederer, Gleitman, & Gleitman, 1995), Hebrew (Geyer, 1998), and Mandarin Chinese (Li, 1994). How did that information get into the input to begin with? Is it there merely by historical accident or is it there as a consequence of grammatical architecture as mentally represented by adult speakers of any language? Could there really have been languages that systematically express, say, one-participant events with transitive verbs and two-participant events with intransitives? Could there have been mental events with adjectival complements and physical events with sentence complements? Our data seem to support the view that the particular associations found in natural languages are determinate rather than adventitious. The theta criterion reflects a formal universal (in the sense of Chomsky, 1965): only grammars built in such a way as to reflect this principle can be learned because learners simply would not imagine that the input they hear would be structured in any other way.

Acknowledgements

This work was supported in part by NIH Grant #DC-00282-202. This work could not

have been completed without the generous assistance of the Central Institute of Indian Languages, Omkar Koul, P.P. Giridhar and A.Y. Vijaykumar.

Appendix A. Materials

Verbs in groups

	A	B	C	D
<i>intr.</i>	<i>hoogu</i> (go) <i>jaaru</i> (slide) <i>horalu</i> (turn)	<i>baru</i> (come) <i>naDugu</i> (shake) <i>tirugu</i> (turn)	<i>naDi</i> (walk) <i>eeru</i> (rise) <i>suTTu</i> (spin)	<i>kuNi</i> (jump) <i>biLu</i> (fall) <i>kantu</i> (hop)
<i>tr.</i>	<i>tikku</i> (rub) <i>hiDi</i> (hold) <i>chuchu</i> (poke)	<i>hoDi</i> (hit) <i>biDu</i> (leave) <i>muTTu</i> (touch)	<i>tabu</i> (hug) <i>ettu</i> (lift) <i>taLLu</i> (push)	<i>jigutu</i> (pinch) <i>eli</i> (pat) <i>tattu</i> (pull)

Subject groups

		Intransitive	Transitive
Group 1			
<i>Intrans</i>	NP V	A	A
<i>Caus Intrans</i>	NP V _{caus}	B	B
<i>Bare Trans</i>	NP NP _{acc} V	C	C
<i>Caus Trans</i>	NP NP _{acc} V _{caus}	D	D
Group 2			
<i>Intrans</i>	NP V	D	D
<i>Caus Intrans</i>	NP V _{caus}	A	A
<i>Bare Trans</i>	NP NP _{acc} V	B	B
<i>Caus Trans</i>	NP NP _{acc} V _{caus}	C	C
Group 3			
<i>Intrans</i>	NP V	C	C
<i>Caus Intrans</i>	NP V _{caus}	D	D
<i>Bare Trans</i>	NP NP _{acc} V	A	A
<i>Caus Trans</i>	NP NP _{acc} V _{caus}	B	B
Group 4			
<i>Intrans</i>	NP V	B	B
<i>Caus Intrans</i>	NP V _{caus}	C	C
<i>Bare Trans</i>	NP NP _{acc} V	D	D
<i>Caus Trans</i>	NP NP _{acc} V _{caus}	A	A

Appendix B. Stimuli

The sentences for groups 1–4 are shown in Figs. 3–6.

- | | |
|--|--|
| 1) * kothi yeth-annu eer-utt-ade
monkey ox-ACC rise-NPST-3SN
'the monkey raises the ox.' | 13) * yedi tirug-is-utt-ade
spider turn-CAUS-NPST-3SN
'the spider turns.' |
| 2) * neeru aane kappe-yannu tatt-is-utt-ade
hippopotamus frog-ACC pat-CAUS-NPST-3SN
'the hippopotamus makes the frog pat.' | 14) * dumbi kothi-yannu el-is-utt-ade
beetle monkey-ACC pull-CAUS-NPST-3SN
'the beetle makes the monkey pull.' |
| 3) miinu mosale-yannu taLL-utt-ade
fish alligator-ACC push-NPST-3SN
'the fish pushes the alligator' | 15) * haavu biDiy-is-utt-ade
snake leave-CAUS-NPST-3SN
'the snake leaves.' |
| 4) * mosale chuch-utt-ade
alligator poke-NPST-3SN
'The alligator pokes.' | 16) * yethu ghenda mruga-vannu jigut-is-utt-ade
ox rhinoceros-ACC pinch-CAUS-NPST-3SN
'the ox makes the rhinoceros pinch.' |
| 5) * chitte tikk-utt-ade
butterfly rub-NPST-3SN
'The butterfly rubs.' | 17) huli jinke-yannu kuN-is-utt-ade
tiger deer-ACC jump-CAUS-NPST-3SN
'the tiger makes the deer jump.' |
| 6) timingala horal-utt-ade
whale turn-NPST-3SN
'The whale turns.' | 18) * kappe halli-yannu suTT-utt-ade
frog lizard-ACC spin-NPST-3SN
'the frog spins the lizard.' |
| 7) * kudure hoDey-is-utt-ade
horse hit-CAUS-NPST-3SN
'the horse hits.' | 19) * aane muTT-is-utt-ade
elephant touch-CAUS-3SN
'the elephant touches.' |
| 8) * huli bar-is-utt-ade
tiger come-CAUS-NPST-3SN
'The tiger brings.' | 20) simha hoog-utt-ade
lion go-NPST-3SN
'The lion goes.' |
| 9) yedi kudure-yannu biiL-is-utt-ade
spider horse-ACC fall-CAUS-NPST-3SN
'the spider makes the horse fall.' | 21) neeru aane jaar-utt-ade
hippopotamus slide-NPST-3SN
'The hippopotamus slides.' |
| 10) timingala chitte-yannu ett-utt-ade
whale butterfly-ACC lift-NPST-3SN
'the whale lifts the butterfly.' | 22) * miinu hiDiy-utt-ade
fish hold-npst-3sn
'The fish holds.' |
| 11) haavu aane-yannu kunt-is-utt-ade
snake elephant-ACC hop-CAUS-NPST-3SN
'the snake makes the elephant hop.' | 23) * jinke naDug-is-utt-ade
deer shake-CAUS-NPST-3SN
'The deer shakes.' |
| 12) simha neeru aane-yannu tab-utt-ade
lion hippopotamus-ACC hug-CAUS-3SN
'the lion hugs the hippopotamus.' | 24) * ghenda mruga dumbi-yannu naD-utt-ade
rhinoceros beetle-ACC walk-npst-3sn
'the rhinoceros walks the beetle.' |

Fig. 3. The sentences for group 1.

- 1) * kothi yeth-annu naDug-utt-ade
monkey ox-ACC shake-NPST-3SN
'the monkey shakes the ox.'
- 2) * neeru aane kappe-yannu taLL-is-utt-ade
hippopotamus frog-ACC push-CAUS-NPST-3SN
'the hippopotamus makes the frog push.'
- 3) miinu mosale-yannu muTT-utt-ade
fish alligator-ACC touch-NPST-3SN
'the fish touches the alligator'
- 4) * mosale tatt-utt-ade
alligator pat-NPST-3SN
'The alligator pats.'
- 5) * chitte jgut-utt-ade
butterfly pinch-NPST-3SN
'The butterfly pinches.'
- 6) timingala kunt-utt-ade
whale hop-NPST-3SN
'The whale hops.'
- 7) * kudure tikk-is-utt-ade
horse rub-CAUS-NPST-3SN
'The horse rubs.'
- 8) * huli hoog-is-utt-ade
tiger go-CAUS-NPST-3SN
'The tiger goes.'
- 9) yedi kudure-yannu eer-is-utt-ade
spider horse-ACC rise-CAUS-NPST-3SN
'The spider makes the horse rise.'
- 10) timingala chitte-yannu biDuttade
whale butterfly-ACC leave-NPST-3SN
'The whale leaves the butterfly.'
- 11) haavu aane-yannu suTT-is-utt-ade
snake elephant-ACC spin-CAUS-NPST-3SN
'the snake makes the elephant spin.'
- 12) simha neeru aane-yannu hoDey-utt-ade
lion hippopotamus-ACC hit-NPST-3SN
'the lion hits the hippopotamus.'
- 13) * yedi horal-is-utt-ade
spider turn-CAUS-NPST-3SN
'the spider turns.'
- 14) * dumbi kothi-yannu ett-is-utt-ade
beetle monkey-ACC lift-CAUS-NPST-3SN
'the beetle makes the monkey lift.'
- 15) * haavu hiDiy-is-utt-ade
snake hold-CAUS-NPST-3SN
'the snake holds.'
- 16) * yethu ghenda mruga-yannu tab-is-utt-ade
ox rhinoceros-ACC hug-CAUS-NPST-3SN
'the ox makes the rhinoceros hug.'
- 17) huli jinke-yannu naD-is-utt-ade
tiger deer-ACC walk-CAUS-NPST-3SN
'the tiger makes the deer walk.'
- 18) * kappe halli-yannu tiruguttade
frog lizard-ACC turn-NPST-3SN
'the frog turns the lizard.'
- 19) * aane chuch-is-utt-ade
elephant poke-CAUS-NPST-3SN
'the elephant pokes.'
- 20) simha kuNiy-utt-ade
lion jump-NPST-3SN
'The lion jumps.'
- 21) neeru aane biIL-utt-ade
hippopotamus fall-NPST-3SN
'The hippopotomus falls.'
- 22) * miinu eliy-utt-ade
fish pull-NPST-3SN
'The fish pulls.'
- 23) * jinke jaar-is-utt-ade
deer slide-CAUS-NPST-3SN
'The deer slides.'
- 24) * ghenda mruga dumbi-yannu bar-utt-ade
rhinoceros beetle-ACC come-NPST-3SN
'the rhinoceros comes the beetle.'

Fig. 4. The sentences for group 2.

- | | |
|--|---|
| 1) * kothi yeth-annu jaar-utt-ade
monkey ox-ACC slide-NPST-3SN
'the monkey slides the ox.' | 13) * yedi kunt-is-utt-ade
spider hop-CAUS-NPST-3SN
'the spider hops.' |
| 2) * neeru aane kappe-yannu muTT-is-utt-ade
hippopotamus frog-ACC touch-CAUS-NPST-3SN
'the hippopotamus makes the frog touch.' | 14) * dumbi kothi-yannu biD-is-utt-ade
beetle monkey-ACC leave-CAUS-NPST-3SN
'the beetle makes the monkey leave.' |
| 3) miinu mosale-yannu chuch-utt-ade
fish alligator-ACC poke-NPST-3SN
'the fish pokes the alligator' | 15) * haavu el-is-utt-ade
snake pull-CAUS-NPST-3SN
'the snake pulls.' |
| 4) * mosale taLL-utt-ade
alligator push-NPST-3SN
'The alligator pushes.' | 16) * yethu ghenda mruga-vannu hoDeyisuttade
ox rhinoceros-ACC hit-CAUS-NPST-3SN
'the ox makes the rhinoceros hit.' |
| 5) * chitte tab-utt-ade
butterfly hug-NPST-3SN
'The butterfly hugs.' | 17) huli jinke-yannu bar-is-utt-ade
tiger deer-ACC come-CAUS-NPST-3SN
'the tiger makes the deer come.' |
| 6) timingala suTT-utt-ade
whale spin-NPST-3SN
'The whale spins.' | 18) * kappe halli-yannu horal-utt-ade
frog lizard-ACC turn-NPST-3SN
'the frog turns the lizard.' |
| 7) * kudure jigut-is-utt-ade
horse pinch-CAUS-NPST-3SN
'the horse pinches.' | 19) * aane tatt-is-utt-ade
elephant pat-CAUS-NPST-3SN
'the elephant pats.' |
| 8) * huli kuN-is-utt-ade
tiger jump-CAUS-NPST-3SN
'The tiger jumps.' | 20) simha naDiy-utt-ade
lion walk-NPST-3SN
'The lion walks.' |
| 9) yedi kudure-yannu naDug-is-utt-ade
spider horse-ACC shake-CAUS-NPST-3SN
'the spider makes the horse shake.' | 21) neeru aane eer-utt-ade
hippopotamus rise-NPST-3SN
'The hippopotomus rises.' |
| 10) timingala chitte-yannu hiDiy-utt-ade
whale butterfly-ACC hold-NPST-3SN
'the whale holds the butterfly.' | 22) * miinu ett-utt-ade
fish lift-NPST-3SN
'The fish lifts.' |
| 11) haavu aane-yannu tirug-is-utt-ade
snake elephant-ACC turn-CAUS-NPST-3SN
'the snake makes the elephant turn.' | 23) * jinke biiL-is-utt-ade
deer fall-CAUS-NPST-3SN
'The deer falls.' |
| 12) simha neeru aane-yannu tikk-utt-ade
lion hippopotamus-ACC rub-NPST-3SN
'the lion rubs the hippopotamus.' | 24) * ghenda mruga dumbi-yannu hoog-utt-ade
rhinoceros beetle-ACC go-NPST-3SN
'the rhinoceros goes the beetle.' |

Fig. 5. The sentences for group 3.

- 1) * kothi yeth-annu biil-utt-ade
 monkey ox-ACC fall-NPST-3SN
 'the monkey falls the ox.'
- 2) * neeru aane kappe-yannu chuch-is-utt-ade
 hippopotamus frog-ACC poke-CAUS-NPST-3SN
 'the hippopotamus makes the frog poke.'
- 3) miinu mosale-yannu tatt-utt-ade
 fish alligator-ACC pat-NPST-3SN
 'the fish pats the alligator'
- 4) * mosale muTT-utt-ade
 alligator touch-NPST-3SN
 'The alligator touches.'
- 5) * chitte hoDey-utt-ade
 butterfly hit-NPST-3SN
 'The butterfly hits.'
- 6) timingala tirug-utt-ade
 whale turn-NPST-3SN
 'The whale turns.'
- 7) * kudure tab-is-utt-ade
 horse hug-CAUS-NPST-3SN
 'the horse hugs.'
- 8) * huli naD-is-utt-ade
 tiger walk-CAUS-NPST-3SN
 'The tiger walks.'
- 9) yedi kudure-yannu jaar-is-utt-ade
 spider horse-ACC slide-CAUS-NPST-3SN
 'the spider makes the horse slide.'
- 10) timingala chitte-yannu eliy-utt-ade
 whale butterfly-ACC pull-NPST-3SN
 'the whale pulls the butterfly.'
- 11) haavu aane-yannu horal-is-utt-ade
 snake elephant-ACC turn-CAUS-NPST-3SN
 'the snake makes the elephant turn.'
- 12) simha neeru aane-yannu jigut-utt-ade
 lion hippopotamus-ACC pinch-NPST-3SN
 'the lion pinches the hippopotamus.'
- 13) * yedi suTT-is-utt-ade
 spider spin-CAUS-NPST-3SN
 'the spider spins.'
- 14) * dumbi kothi-yannu hiDiy-is-utt-ade
 beetle monkey-ACC hold-CAUS-NPST-3SN
 'the beetle makes the monkey hold.'
- 15) * haavu ett-is-utt-ade
 snake lift-CAUS-NPST-3SN
 'the snake lifts.'
- 16) * yethu ghenda mruga-yannu tikk-is-utt-ade
 ox rhinoceros-ACC rub-CAUS-NPST-3SN
 'the ox makes the rhinoceros rub.'
- 17) huli jinke-yannu hoog-is-utt-ade
 tiger deer-ACC go-CAUS-NPST-3SN
 'the tiger makes the deer go.'
- 18) * kappe halli-yannu kunt-utt-ade
 frog lizard-ACC hop-NPST-3SN
 'the frog hops the lizard.'
- 19) * aane taLL-is-utt-ade
 elephant push-CAUS-NPST-3SN
 'the elephant pushes.'
- 20) simha bar-utt-ade
 lion come-NPST-3SN
 'The lion comes.'
- 21) neeru aane naDug-utt-ade
 hippopotamus shake-NPST-3SN
 'The hippopotamus shakes.'
- 22) * miinu biD-utt-ade
 fish leave-NPST-3SN
 'The fish leaves.'
- 23) * jinke eer-is-utt-ade
 deer rise-CAUS-NPST-3SN
 'The deer rises.'
- 24) * ghenda mruga dumbi-yannu kuNiy-utt-ade
 rhinoceros beetle-ACC jump-NPST-3SN
 'the rhinoceros jumps the beetle.'

Fig. 6. The sentences for group 4.

Appendix C. Coding scheme

STEP 1: For each child enactment, write a description, using one of the following possibilities. The target sentence is of the form X Verb (Y) (Prep Z)

1. X pushes or carries Y
2. X moves behind moving Y
3. X&Y move together, then Y is left at destination and X returns
4. X&Y held in same hand as they move
5. X hits stage, then Y moves
6. X moves a pantomimed Y
7. X knocks over or hits Y
8. X is held close to Y and then Y falls
9. X stands on or in front of Y
10. X is held close to Y, but only Y moves
11. X is out or moves alone
12. X&Y are out, but there is no movement and no obvious spatial relationship between them
13. X&Y move separately
14. X&Y face each other
15. X or Y act on Z
16. X combs Y
17. X moves slowly and with great effort
18. X follows Y
19. X moves to or away from Y
20. Y or Z act on X
21. X moves to or away from Z

STEP 2: Compare each grammatical sentence w/its enactment. Is the enactment correct? For transitive sentences, correct enactments are #1–8. For intransitive sentences, correct enactments are 10, 11, 19, 21.

STEP 3: Code ungrammatical sentences for causative/noncausative (or frame/verb compliance). For ungrammatical 2arg sentences, causative act-outs are 1–8; all other enactments are noncausative. For ungrammatical 1arg sentences, noncausative act-outs (frame compliant) are 9–21.

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