REPORT

Fast mapping between a phrasal form and meaning

Devin Casenhiser[1] and Adele E. Goldberg[2]

1. The Milton & Ethel Harris Research Initiative, York University, Canada
2. Program in Linguistics, Council of Humanities, Princeton University, USA

Abstract

This is the first study to investigate experimentally how children come to learn mappings between novel phrasal forms and novel meanings: a central task in learning a language. Two experiments are reported. In both studies 5- to 7-year-old children watched a short set of video clips depicting objects appearing in various ways. Each scene was described using a novel verb embedded in a novel construction. Children who watched the videos and heard the accompanying description were able to match new descriptions that used the novel construction with new scenes of appearance. Moreover, our results suggest a facilitative effect for the disproportionately high frequency of occurrence of a single verb in a particular construction (such as has been found to exist in naturalistic input to children). While the fast mapping might be taken as an indication of innate knowledge that is specific to language, analogous effects in non-linguistic categorization tasks suggest that children are acquiring the new phrasal form with general cognitive skills.

Introduction

Children learning language must come to know correlations between phrasal patterns and meanings, so that when they hear novel verbs in utterances such as *She text-messaged him the directions*, they are able to discern in a general way what that new utterance means: in this case something like 'She GAVE him the directions using text messaging' (Goldberg, 1995; Landau & Gleitman, 1985). This is something on which all linguistic and psycholinguistic theories agree; there exist correlations between phrasal forms and meanings, whether they be called 'linking rules', 'mapping principles' or 'constructions'. The results reported here demonstrate that with quite minimal input, children can learn these correlations between phrasal patterns and meaning and can generalize on the basis of them. Moreover, we demonstrate that the learning is facilitated by a high number of instances of a single verb type. This sort of statistical 'skewing' of the input, where a restricted subset of types of utterances accounts for the preponderance of total utterances, is exactly what is found in naturalistic speech to children for a number of types of language patterns (Cameron-Faulkner, Lieven & Tomasello, 2003; Diessel, 2002; Thompson & Hopper, 2001). Thus the learning mechanism demonstrated here may have a fairly general utility, allowing learners to get an initial fix on many types of form–meaning mappings in language; this may offer a way

that learners can crack into the system of learning to use language in an infinitely creative way.

Recent work has demonstrated that statistical regularities enable children to learn formal generalizations in phonotactics (Chambers, Onishi & Fisher, 2003; Saffran, Aslin & Newport., 1996), in aspects of syntax (Saffran, 2001, 2002) and in lexical acquisition (Childers & Tomasello, 2002). For example, Saffran has investigated the role of conditional probabilities in implicit learning of word forms and simple phrase structure rules, and Childers and Tomasello have demonstrated an advantage for temporally spaced versus temporally massed exposure in word learning.

Previous work on the acquisition of linking rules (or 'constructions') has focused almost entirely on the question of whether the linking rules have been acquired at a certain age rather than on particular factors that facilitate or inhibit the learning of the mappings (Fisher, 1996; Naigles, 1990; Tomasello, 2000). For example, researchers have investigated the extent to which children are willing to use non-English word orders for messages normally expressed with standard transitive (SVO) order. It turns out that young children will use novel orders when novel verbs are modelled in those orders, but resist using the novel order for already-known verbs (Abbot-Smith, Lieven & Tomasello, 2001; Akhtar, 1999). As children become older and gain more experience with English, they are systematically more reluctant to use novel verbs in the novel word order that was modelled for them. Instead, they convert the novel

word order into the familiar standard transitive (SVO) order. These experiments demonstrate the item-based nature of early learning: younger children are aware of how already-learned verbs are used in the language, but are willing to use a novel phrasal pattern for novel verbs; older children much more systematically draw on their growing knowledge of the language, making their productions conform to the language's generalizations. That is, older children produce SVO order much more consistently, even for novel verbs (e.g. Tomasello, 2000, 2003).

Childers and Tomasello (2002) is the only training study that has found a facilitating factor in the learning of linking rules, namely the use of pronouns instead of full NP arguments in the acquisition of the English transitive construction (there is also some facilitative effect of pronouns in Akhtar, 1999); Abbot-Smith, Lieven and Tomasello (2004) looked for other facilitative factors, including semantic relatedness and shared syntactic distribution, but found null results.

None of these studies reproduces the entire task that young children face when learning a novel construction. Previous experimental tasks have required children to learn a novel word order to be sure, but they have not required children to map a novel meaning onto a novel word order. Rather, the meaning involved has been simple transitivity (an actor acting on a patient argument). In fact there have been no studies that we are aware of that investigate how children learn grammatical patterns that are paired with *novel meanings*.

To some extent the lack of experimental work on facilitory or inhibitory factors in the learning of novel form–meaning correspondences has been due to the fact that many researchers believe that these kinds of mappings are innate, therefore essentially eliminating the need to learn them from the input. Linking rules have been claimed to be 'near-universal in their essential aspects and therefore may not be learned at all' (Pinker, 1989, p. 248). Claims that linking rules are universal are widespread (e.g. Baker, 1988; Gleitman, 1994; Levin & Rappaport Hovav, 1995; Pinker, 1989). The implication has been that universal aspects of language are innate, proposed specifically to solve the 'poverty of the stimulus' problem (Chomsky, 1957, 1965). Pinker (1989) offers the following proposal for the mappings from semantic roles to surface syntactic positions:

1. Link the agent to SUBJECT;
2. Link the patient to OBJECT;
3. Link the theme argument (first argument of BE or GO) to SUBJECT unless SUBJECT is already linked; to OBJECT otherwise;
4. Link the goal to an OBLIQUE (prepositional phrase) argument.

Naigles, Gleitman and Gleitman (1993) likewise suggest that 'there is sufficient cross-linguistic similarity in these linking rules to get the learning procedure started . . . there is an overwhelming tendency, cross-linguistically, for agents to appear as subjects and themes as direct objects, with other arguments appearing in oblique cases' (pp. 136–137). Baker (1996, p. 1) echoes a similar theme: 'One central task for any theory of grammar is to solve the so-called "linking problem": the problem of discovering regularities in how participants of an event are expressed in surface grammatical forms.'

If the statistical nature of the input can be demonstrated to be relevant to the learning of linking generalizations in addition to the acquisition of formal domains such as phonology, word forms and constituent boundaries, then it would reduce the necessity of invoking biologically fixed, universal grammar to account for the mappings. This would be advantageous insofar as accounts that rely on a universal grammar fail to predict the item-based, or bottom-up way that children appear to learn language. Moreover, recognizing that form–meaning mappings can be learned from the input allows for substantial variation in the mappings across languages, variation that in fact has been argued to exist (Bowerman, 1990; Bowerman & Brown, in press; Croft, 2001). At the same time, it would raise the further question of whether the learning mechanism involved might be specific to the learning of language, or whether the learning strategy is instead general to cognition.

The present work is motivated by an analysis of naturalistic data which has shown that a single verb typically accounts for the lion's share of tokens of each of several simple patterns in the input speech of mothers to young children (Goldberg, 1998; Goldberg, Casenhiser & Sethuraman, 2004; Ninio, 1999). For example, in the Bates *et al.* (1988) corpus of speech between mothers and children, *put* fills the verb slot in roughly 40% of the instances of the phrasal pattern in mothers' speech, <Subject – Verb – Object – Locative Phrase>; *give* fills the verb slot in roughly 20% of the phrasal pattern <Subject – Verb – Object1 – Object2>; and *go* fills the verb slot in roughly 40% of the phrasal pattern <Subject – Verb – Locative Phrase>.

Moreover, the meaning associated with highly frequent verbs like *put, give* and *go* has been independently claimed to encode the semantics associated with the phrasal pattern in which these verbs occur so frequently (Goldberg, 1995; Pinker, 1989). For example, the verb *put* and the phrasal pattern with which it is associated convey a 'caused motion' meaning, roughly, 'to cause something to move to a location'. That the phrasal pattern, <Subject – Verb – Object – Locative Phrase>, does in fact suggest such a meaning becomes apparent by

Table 1 *Fifteen mothers' most frequent verb and number of verb types for 3 constructions in Bates* et al. *(1988) corpus (from Goldberg* et al., *2004)*

Construction	Mothers	Total number of verb types
1. Subj V Loc	39% *go* (136/353)	39 verbs
2. Subj V Obj Obl	38% *put* (99/256)	43 verbs
3. Subj V Obj Obj2	20% *give* (11/54)	13 verbs

Note: The percentage of uses of *give* in the ditransitive is somewhat less striking than the percentages of *go* and *put* in the intransitive and caused motion constructions, respectively. However, that is likely an effect of the small sample size together with the particular situation recorded. *Tell*, in our small sample of 54, appeared an equal number of times as *give*. We believe the high number of instances of *tell* is an artifact of the book-reading context, since only one instance occurred in a non-story context. The other 10 occurrences are all directly related to the task of reading the story; in fact the second object in 8 out of 10 instances is *story*. Bresnan and Nikitina report that *give* accounts for 226/517, or 44% of the instances of the ditransitive in the parsed Switchboard corpus (Bresnan & Nikitina, 2003).

considering a sentence such as *Pat mooped the feather onto the table*. Although it is not certain exactly what *mooped* means, it seems clear from the sentence that the feather in question has somehow found its way to the table with the help of Pat.

Experiment 1

Since the input is typically structured such that a small subset of types account for the preponderance of utterances, we hypothesized that the existence of a single verb occurring in a particular construction with a disproportionately high frequency might facilitate the association of a meaning with a phrasal pattern, when overall type and token frequencies were controlled for. To test this, we created a novel, non-English phrasal pattern associated with a novel meaning – that of appearance. Sentences involving the novel word order were paired with film clips in which a puppet or toy object spontaneously appeared in the scene in some way. We then divided subjects into three groups: (1) the *skewed frequency group* watched the film and heard a corresponding set of sentences in which one novel verb occurred in half of the sentences; (2) the *balanced frequency group* watched the same film and heard a set of sentences in which each of the novel verbs occurred with roughly equal frequency; and (3) the *control group* watched the same film with the sound turned off. In both training conditions, subjects each saw 16 film clips paired with sentences involving a total of five different novel verbs; they differed in whether or not a single novel verb occurred in a preponderance of the sentences.

Subjects were tested with a forced-choice comprehension task in which they were asked to identify which of two scenes corresponded to the sentence being played on the audio track. Each test item paired a new scene of appearance with a foil scene that was similar to the appearance scene but lacked any appearance component. Each item on the audio track used a new novel verb (i.e. one that was not used in the training portion of the experiment). The forced-choice comprehension task is reminiscent of the widely used preferential looking paradigm, except that we required an unambiguous behavioural response from subjects indicating their choice between the two scenes instead of comparing looking times (i.e. they were asked to touch the scene that corresponded to the audio description).

Method

Participants

Fifty-one native English speaking children aged 5–7 (mean = 6;4) were recruited from two elementary schools in Champaign-Urbana, Illinois.

Procedure

A single training film was prepared that contained eight clips of puppets performing various actions. The same film was presented twice to each subject (for a total of 16 video clips). In the non-control conditions, we paired each clip in the film with audio descriptions of the scene and arranged the words in the description according to a novel phrasal pattern that we created. The novel pattern involved two known nouns along with a nonsense verb. The constituents were arranged in the form <NOUN PHRASE$_1$ – NOUN PHRASE$_2$ – NONSENSE VERB + *o*>. At the beginning of each scene, subjects heard a simple present tense version of the sentence; at the end of the scene, they heard the corresponding past tense version of the sentence. For example, given a video clip in which a rabbit appeared in a hat, the corresponding description was 'The rabbit the hat moopo-s . . . The rabbit the hat moopo-ed.' See Table 2 for details.

The meaning of the phrasal pattern was that of appearance (a meaning novel for English phrasal patterns): the entity named by the first noun phrase comes to exist in the place named by the second noun phrase. For example, the intended meaning for the sentence *the sailor the pond neebod* was 'the sailor sailed onto the pond from out of sight' as opposed to, for example, 'the sailor sailed (around) the pond'.

In a between-subjects experimental design, subjects were randomly assigned to one of three conditions that varied the frequencies of input exemplar nonsense verbs. Each group viewed a video that included eight different

Table 2 *Training stimuli (8 film clips viewed* TWICE*; randomized order; between-subjects design)*

Scene displayed on video	BALANCED FREQUENCY (2 *moopo*; 2 *vako*; 2 *suto*; 1 *keebo*; 1 *fego*)	SKEWED FREQUENCY (4 *moopo*; 1 *vako*; 1 *suto*; 1 *keebo*; 1 *fego*)
The rabbit appears on a hat.	*The rabbit the hat moopoed.*	*The rabbit the hat moopoed.*
The monster wiggles out from under a cloth.	*The monster the cloth keeboed.*	*The monster the cloth keeboed.*
The frog drops down onto box.	*The frog the box vakoed.*	*The frog the box moopoed.*
The king drops down into a chair.	*The king the chair vakoed.*	*The king the chair vakoed.*
The sun rises into the sky.	*The sun the sky fegoed.*	*The sun the sky fegoed.*
The queen rolls onto the stage.	*The queen the stage sutoed.*	*The queen the stage sutoed.*
The bug appears onto a table.	*The bug the table moopoed.*	*The bug the table moopoed.*
The ball rolls into the room.	*The ball the room sutoed.*	*The ball the room moopoed.*

scenes of appearance. The *balanced frequency* condition heard five nonsense verbs paired with video clips; two verbs occurred once and three verbs occurred twice (1-1-2-2-2). The *skewed frequency* condition also heard five nonsense verbs used in the novel phrasal pattern, but one nonsense verb was heard four times while the other four verbs were heard only once each (4-1-1-1-1). Subjects in the control condition saw the identical film but heard no language. The training film was played twice for each of the three groups, so that children in all three groups saw a total of 16 scenes. The total length of the training session was less than 3 minutes.

The test was a forced-choice comprehension task: subjects saw two *new* film clips presented side-by-side on the screen and heard a sentence describing one of the clips (sample film clips are available at http://www.princeton.edu/~adele/fastmap). There were 12 items in the testing phase: in addition to the six test items, six filler items were included to help mask the purpose of the experiment. The six test items showed two side-by-side scenes portraying the same objects/characters engaged in similar actions. The two scenes differed crucially in that one scene depicted a character appearing in the scene whereas the other scene depicted that character performing an action while remaining in constant view (e.g. in one case, a sailor sails in on a boat from off the screen; in the paired foil clip, the sailor sails around in a boat on screen). The audio track played a description of the scene using a *new* novel verb (i.e. one that was not heard during training) in the appearance construction (e.g. 'the sailor the pond neebos'). The filler items were similarly composed except that the scenes differed in transitivity (one scene depicted a transitive action and one depicted an intransitive action) and the audio track played a novel verb used in a simple transitive frame (i.e. NP V NP).

As each film was played, subjects were asked to point to the film clip that corresponded to the description that they heard. In practice trials, subjects were trained to touch the film clip on the computer screen, so that responses would be unambiguous. This training was successful and the responses (pointing gestures) were unambiguous. Responses were coded for accuracy. Any difference among groups can only be attributed to a difference in the linguistic input that subjects were exposed to, as all three conditions watched exactly the same video.

Results

An ANOVA confirmed a significant main effect for group, $F_{2, 48} = 11.57$, $p < .001$. Planned comparisons analysed with Fisher's PLSD show that both the skewed frequency and the balanced groups performed significantly better than the control group ($p < .001$ and $p < .05$, respectively). Moreover, the skewed frequency group performed significantly better than the balanced frequency group ($p < .01$). In a comparison to chance performance, a one-sample *t*-test shows that while the score of the control group did not differ significantly from a chance score of 3 ($t(16) = .37$; $p > .05$), the scores of the balanced ($t(16) = 2.63$; $p < .01$) and the skewed frequency groups ($t(16) = 8.29$; $p < .001$) were significantly greater than would be expected from chance performance. The results of the experiment show that after only 3 minutes of training, children in the balanced frequency and skewed frequency groups learned to associate a novel meaning with a novel phrasal pattern. Moreover, the skewed frequency group performed significantly better than the balanced frequency group, confirming the hypothesis that learning is facilitated when one verbal token accounts for the majority of utterances.

Similar results have been found for adults (Goldberg *et al.*, 2004); in the adult experiment, each nonsense verb was matched with a specific type of action, so that the two training conditions saw slightly different films. In addition, the control condition in the previous experiment did not watch the film but went straight to test. The present experiment rules out the possibility that the visual scenes
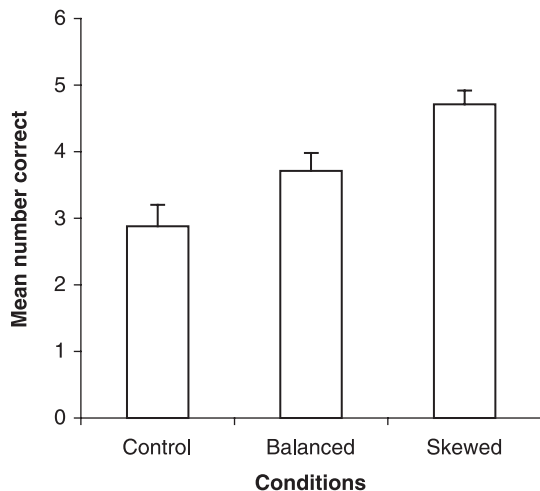
Figure 1   *Mean number of times subjects were able to correctly match the scene of appearance to the novel phrasal pattern (out of 6).*

are responsible for the effects, because children in all conditions watched exactly the same video.[1]

Experiment 2

Although the results from Experiment 1 suggest that children can learn to associate a phrasal form with a particular meaning, the experiment raises some questions about how children are able to do this, and what it is that they actually learned. In particular, the sentences from Experiment 1 included an *–o* morpheme that was suffixed to each of the novel verbs in the scenes of appearance. Experiment 2 investigates whether children are able to learn the novel form–meaning pairing in the absence of such a morphological cue. Accordingly, we omitted the *–o* morpheme from the novel verbs so that children were forced to attend solely to differences in word order.

A second question that arises from Experiment 1 is what effect the training has on children's ability to distinguish

[1] A possibly related effect has been found in studies by Hudson and Newport. They trained subjects on a novel toy grammar that included learning determiners. In one study (Hudson & Newport, 1999), no single determiner accounted for the preponderance of tokens, and determiners were indistinguishable semantically. Faced with this input, subjects did not regularize the pattern in any way; they produced determiners in much the same percentages that they had heard them used. At the same time, in a follow-up, as yet unpublished, study (Elissa Newport, personal communication), one determiner was heard 60% of the time in training, while several other determiners were heard (again, without a change in meaning) with lower frequencies; in the latter study, subjects did show evidence of regularizing the pattern; they used the determiner that had accounted for the preponderance of the input as much as 90% of the time.
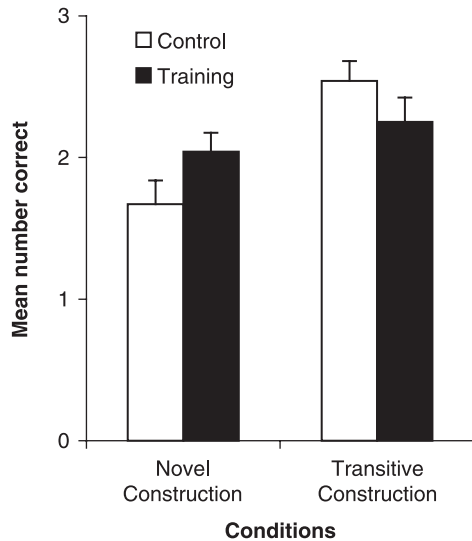
between a novel form–meaning pairing and a known form–meaning pairing such as the simple transitive construction. In other words, Experiment 1 tests only whether children have learned to identify the scene of appearance. It is possible that children would point to the scene of appearance even when presented with a sentence exhibiting a simple transitive construction with a novel verb (<subject> <verb> <object>). Accordingly, we included three transitive stimuli at test as well as three instances of the novel construction. We also modified the forced-choice stimuli so that each contained both a scene of appearance and a matched transitive scene: for example, in one video pair the scene of appearance involves a balloon entering from off stage in front of a dragon puppet; the matched transitive scene shows the same dragon puppet squeezing the balloon. If the child hears 'The dragon the balloon lems', the correct response is to choose the former scene; if the child hears 'The dragon lems the balloon', the correct choice would be the transitive scene.

Method

Forty-eight children aged 5;0–7;6 (mean age 6;3) recruited from after-school programmes in the Menlo Park, California area were randomly and equally divided into two conditions: the training condition and the control condition. In the training condition, subjects witnessed the same skewed frequency training film as in Experiment 1: 16 film clips of scenes of appearance were viewed, each paired with a description involving the novel construction. As in Experiment 1, the control condition watched the same video without sound.

In the forced-choice comprehension test, children heard three new instances of the novel appearance construction and three new instances of the familiar transitive construction (also involving new instances in the sense that different novel verbs were used). Responses were coded for accuracy.

Results

Responses for the transitive construction and for the novel appearance construction were coded separately. As shown in Figure 2, children were able to identify the novel construction and associate it with its meaning of appearance more often after training than in the control condition in which they watched the same video without sound. Based on Experiment 1 and results from previous experiments with adult subjects (Goldberg *et al.*, 2004), we expected that training would help children learn the novel construction. An independent samples *t*-test confirmed that the group that received training did perform significantly better than the control group which

Figure 2 *Average number of correct responses for the novel and transitive constructions (out of 3).*

received no training: $t(46) = 1.718$; $p < .05$ (one-tailed). Since in this experiment no morphological cue was present, subjects had to learn to distinguish the novel construction from the transitive construction based on word order alone.

There is some indication that the learning in Experiment 1 was aided by the stable morphology insofar as children in the skewed frequency condition in Experiment 1 chose the correct response 78% of the time as opposed to 68% of the time in Experiment 2. Moreover, the results were not as robust as in Experiment 1 – a two-tailed *t*-test would have shown only a marginal effect. However, since different foil films were paired with the test items in the two experiments, these results cannot be reliably compared directly.

As expected, subjects in both the transitive and control conditions demonstrated a familiarity with the transitive construction, choosing the transitive scene over the scene of appearance when faced with a novel transitive utterance more often than chance (for a one-sample *t*-test: control condition is $t(23) = 7.76$; $p < .001$; training condition is $t(23) = 4.34$; $p < .001$). The training on the novel construction did nothing to improve accuracy on the already familiar transitive construction; an independent samples *t*-test did not find a difference between the training and control conditions $t(46) = 1.33$; $p > .05$ (two-tailed). (While a one-tailed *t*-test would have indicated a marginal effect, only a two-tailed test was justified because we had no prior expectations about whether controls or training should do better on transitives, not having been tested on transitives previously.) Also as expected, the control group performed better on the

transitive construction than on the novel construction ($t(23) = 4.53$; $p < .001$). Subjects who were trained on the novel construction performed equally well on both the novel construction and on the transitive sentences ($t(23) = 1.05$; $p > .05$). Thus, while all children displayed an ability to recognize the English transitive construction, only the children who received the training were able to successfully recognize that the meaning of appearance was associated with the novel word order.

Discussion

It is possible that the quick learning of the mapping could be taken as an indication that the particular mapping is a part of universal grammar and is innately available. A mapping between subject and thing coming to exist, on the one hand, and displaced noun phrase and location on the other, could be added to the set of mapping principles sometimes claimed to be universal. However, we know of no language that has a general mapping that encodes 'appearance' in this way. In particular, the mapping violates at least one of the proposed universal linking rules suggested by both Pinker (1989) and Naigles *et al.* (1993): namely the generalization that a locative argument should be expressed by an oblique complement. The location arguments used in the experiments would require prepositional marking to be considered obliques in English; yet they were simple noun phrases in the experimental stimuli. Thus, given its cross-linguistic rarity, there is no independent reason to believe that the particular generalization learned in the study reported here is innately available.

Moreover, there is reason to suspect that the learning *mechanism* is not specific to language, but is general to cognition insofar as work in the non-linguistic category literature has found a parallel facilitory factor to that reported here. That is, there is an advantage to training on low-variance input, and on prototypical instances before more varied input in the learning of non-linguistic categories (Elio & Anderson, 1984; Homa, Dunbar & Nohre, 1991; Nosofsky, 1988; Rosch & Mervis, 1975). For example, there is a strong correlation between the frequency with which a token occurs and the likelihood that it will be considered a prototypical member by the learner (Posner, Goldsmith & Welton, 1967; Posner & Keele, 1968; Rosch & Mervis, 1975). Homa *et al.* (1991) found that token frequency was an important variable at early and intermediate stages of category learning, with increased token frequency facilitating category learning. In learning generalizations about dot patterns, Posner, Goldsmith and Welton (1967) demonstrated that the rate at which subjects classified patterns correctly was a direct function of the amount of distortion from their

respective prototypes: the less variability or distortion, the faster the category was learned.

Elio and Anderson's (1984) non-linguistic category learning experiment set up two conditions: in the 'centered' condition, subjects were initially trained on more frequently represented, more prototypical instances, with the study sample growing gradually to include the full range of members in the category; in the 'representative' condition, subjects were trained on a fully representative sampling from the start. Categories were learned more accurately in the centred condition, yielding better typicality ratings and accuracy during the test phase on new instances.

Gentner likewise notes that processes of analogy required for generalization (her 'structural alignment') is facilitated when instances being compared are similar to one another. Gentner, Loewenstein and Hung (2002) performed an experiment that illustrates this idea: they showed children a particular picture of a Martian to be used as a standard for comparison, and two alternative Martian creatures. The standard Martian and one of the alternatives shared one body part, while the distinct Martian didn't. Children were asked, 'This one has a *blick*; which one of these has a *blick*?' The results demonstrated that if the two alternatives were highly similar to the standard, children were better able to pick out the relevant shared body part; when they were only weakly similar, finding the body part was more difficult. In addition, Gentner *et al.* demonstrated that children who were tested in the high-similarity condition first, were subsequently more successful on the low-similarity items than children who had the same amount of experience with only low-similarity items.

Moreover, categories that are identifiable with a salient type of stable feature are easier to learn than categories in which the feature is instantiated in different ways, even when the variability is relevant to the feature dimension (Markman & Maddox, 2003). The analogy to language is that constructions that are instantiated (to a great extent) by a single verb should be initially easier to learn than constructions that are instantiated by many different verbs. This is in fact the same pattern that we found in Experiment 1 where children were more successful in the forced-choice task when their training set included one predominantly frequent verb as opposed to a set with verbs occurring in more balanced frequency.

The present experiments concern construction learning and not verb learning. We know this because the children were tested on the novel construction with *new* novel verbs, unwitnessed during the training. In addition, Experiment 2 demonstrates that children are more likely to attribute the novel construction meaning of appearance to *The flower the grass naifs* than to *The monster naifs the balloon*. All verbs used at test were new

novel verbs, so the discrimination had to be made on the basis of the different constructions.

These experiments are only a beginning; clearly work on younger children is needed to demonstrate that the categorization strategies at play in the experiments reported here are operative at younger ages, when children actually begin to acquire language. At the same time, it is intriguing that children at age 6 were able to successfully induce the semantics associated with the novel grammatical pattern because the knowledge of English that older children brought to the experiment might have been expected to mislead or confuse them. This is because the construction that was used in training is quite distinct from other English patterns in that both arguments are expressed preverbally, without any preposition or special intonation. Recall also that in the training studies involving novel word orders with a familiar meaning, older children resisted using the novel word order more than younger children. Of course the present study is different in at least two critical ways: (1) the present studies exposed children to novel mappings of both form and *meaning* and (2) the test in the present studies was a forced-choice comprehension task, while the earlier studies required children to productively use the novel pattern. Since older children in previous experiments were already well familiar with the transitive construction, they avoided expressing the transitive message with an entirely new form. In our experiment, children came to learn that a new meaning was associated with the novel form. When asked to identify the meaning associated with the novel form, they were able to do so.

Also in need of further exploration are the motivations for the cross-linguistic generalizations that exist. While it has been argued that claims of universal status have been exaggerated (Bowerman, 1990; Bowerman & Brown, in press; Croft, 2001), there do appear to be a few candidates for truly universal tendencies, if not hard and fast rules; for example, the number of complements expressed tends to correspond to the number of semantic arguments in the message. Also, agentive arguments tend to be expressed in topical positions. These sorts of cross-linguistic convergences require explanation. The suggestion is that these sorts of generalizations are based on general cognitive, pragmatic and processing constraints rather than requiring recourse to innate knowledge that is specific to language (see e.g. Goldberg, 2004, and Goldberg, 2006, Chapter 11, for discussion).

Conclusion

We have found that pairings of novel phrasal patterns and novel meanings are generalized with remarkable

speed. When they are instantiated predominantly by a single verb, they are generalized even more effectively. Initial learning of the meaning associated with a novel word order occurs even when no stable morphological cue is present. The facility effect of a single exemplar with high token frequency is paralleled in non-linguistic categorization tasks, providing an indication that the learning mechanism is not specific to language. Since natural linguistic input tends to be skewed in this way, it seems that the associations of form and meaning that exist in languages do not need to be hard wired or universal – children are quite expert at learning the mappings, given general categorization strategies.

Acknowledgements

References

Abbot-Smith, K., Lieven, E., & Tomasello, M. (2001). What preschool children do and do not do with ungrammatical word orders. *Cognitive Development*, **16**, 679–692.

Abbot-Smith, K., Lieven, E., & Tomasello, M. (2004). Training 2;6-year-olds to produce the transitive construction: the role of frequency, semantic similarity and shared syntactic distribution. *Developmental Science*, **7**, 48–55.

Abeillé, A., & Godard, D. (1997). *French word order and the word phrase distinction*. Stanford, CA: Stanford University Press.

Akhtar, N. (1999). Acquiring word order: evidence for data-driven learning of syntactic structure. *Journal of Child Language*, **26** (2), 339–356.

Baker, M. (1988). *Incorporation: A theory of grammatical function changing*. Chicago, IL: University of Chicago Press.

Baker, M. (1996). On the structural positions of themes and goals. In J. Rooryck & L. Zaring (Eds.), *Phrase structure and the lexicon* (pp. 7–24). Dordrech: Kluwert.

Bates, E., Bretherton, I., & Snyder, L. (1988). *From first words to grammar: Individual differences and dissociable mechanisms*. New York: Cambridge University Press.

Bowerman, M. (1990). Mapping thematic roles onto syntactic functions: are children helped by innate linking rules? *Linguistics*, **28** (6), 1253–1289.

Bowerman, M., & Brown, P. (Eds.) (in press). *Crosslinguistic perspectives on argument structure: Implications for learnability*. Hillsdale, NJ: Lawrence Earlbaum.

Bresnan, J., & Nikitina, T. (2003). On the gradience of the dative alternation. Stanford University.

Cameron-Faulkner, T., Lieven, E., & Tomasello, M. (2003). A construction based analysis of child directed speech. *Cognitive Science*, **27**, 843–873.

Chambers, K., Onishi, K., & Fisher, C. (2003). Infants learn phonotactic regularities from brief auditory experience. *Cognition*, **87**, B69–B77.

Childers, J., & Tomasello, M. (2001). The role of pronouns in young children's acquisition of the English transitive construction. *Developmental Psychology*, **37**, 739–748.

Childers, J., & Tomasello, M. (2002). Two-year-olds learn novel nouns, verbs, and conventional actions from massed or distributed exposures. *Developmental Psychology*, **38**, 967–978.

Chomsky, N. (1957). *Syntactic structures*. Berlin: Mouton.

Chomsky, N. (1965). *Aspects of the theory of syntax*. Cambridge, MA: MIT Press.

Croft, W. (2001). *Radical construction grammar*. Oxford: Oxford University Press.

Diessel, H. (2002). The development of complex sentence constructions in English. A usage-based approach. Unpublished Habilitation thesis, University of Leipzig.

Elio, R., & Anderson, J.R. (1984). The effects of information order and learning mode on schema abstraction. *Memory and Cognition*, **12** (1), 20–30.

Fisher, C. (1996). Structural limits on verb mapping: the role of analogy in children's interpretations of sentences. *Cognitive Psychology*, **31** (1), 41–81.

Gentner, D., Loewenstein, J., & Hung, B.T. (2002). Comparison facilitates learning part names. Unpublished manuscript.

Gleitman, L. (1994). The structural sources of verb meanings. In P. Bloom (Ed.), *Language acquisition: core readings* (pp. 174–221). Cambridge, MA: MIT Press.

Goldberg, A.E. (1995). *Constructions: A construction grammar approach to argument structure*. Chicago, IL: Chicago University Press.

Goldberg, A.E. (1998). The emergence of the semantics of argument structure constructions. In B. MacWhinney (Ed.), *The emergence of language* (pp. 197–212). Hillsdale, NJ: Lawrence Erlbaum Associates.

Goldberg, A.E. (2004). But do we need Universal Grammar? A comment on Lidz *et al.* (2003). *Cognition*, **94** (1), 77–84.

Goldberg, A.E. (2006). *Constructions at work: The nature of generalization in language*. Oxford: Oxford University Press.

Goldberg, A.E., Casenhiser, D.M., & Sethuraman, N. (2004). Learning argument structure generalizations, *Cognitive Linguistics*, **15**, 289–316.

Homa, D., Dunbar, S., & Nohre, L. (1991). Instance frequency, categorization, and the modulating effect of experience. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **17** (3), 444–458.

Hudson, C., & Newport, E. (1999). Creolization: could adults really have done it all? In A. Greenhill, A. Littlefield, & C. Tano (Eds.), *Proceedings of the Boston University conference on language development* (Vol. 23, pp. 265–276). Comerville, MA: Cascadilla.

Landau, B., & Gleitman, L.R. (1985). *Language and experience: Evidence from a blind child*. Cambridge, MA: Harvard University Press.

Levin, B., & Rappaport Hovav, M. (1995). *Unaccusativity in the syntax–lexical semantics interface*. Cambridge, MA: MIT Press.

Markman, A.B., & Maddox, W.T. (2003). Classification of exemplars with single and multiple-feature manifestations: the effects of relevant dimension variation and category structure. *Journal of Experimental Psychology: Learning, Memory and Cognition*, **29** (1), 107–117.

Naigles, L. (1990). Children use syntax to learn verb meanings. *Journal of Child Language*, **17**, 357–374.

Naigles, L., Gleitman, H., & Gleitman, L. (1993). Children acquire word meaning components from syntactic evidence. *Language and Cognition: A Developmental Perspective*, **5**, 104–140.

Ninio, A. (1999). Pathbreaking verbs in syntactic development and the question of prototypical transitivity. *Journal of Child Language*, **26**, 619–653.

Nosofsky, R. (1988). Similarity, frequency and category representations. *Journal of Experimental Psychology: Learning, Memory and Cognition*, **14** (1), 54–65.

Pinker, S. (1989). *Learnability and cognition: The acquisition of argument structure*. Cambridge, MA: MIT Press/Bradford Books.

Posner, M.I., Goldsmith, R., & Welton, K.E.J. (1967). Perceived distance and the classification of distorted patterns. *Journal of Experimental Psychology: General*, **73** (1), 28–38.

Posner, M.I., & Keele, S.W. (1968). On the genesis of abstract ideas. *Journal of Experimental Psychology*, **77** (3.1), 353–363.

Rosch, E., & Mervis, C.B. (1975). Family resemblances: studies in the internal structure of categories. *Cognitive Psychology*, **7**, 573–605.

Saffran, J.R. (2001). The use of predictive dependencies in language learning. *Journal of Memory and Language*, **44**, 493–515.

Saffran, J.R. (2002). Constraints on statistical language learning. *Journal of Memory and Language*, **47** (1), 172–196.

Saffran, J.R., Aslin, R.N., & Newport, E.L. (1996). Statistical learning by 8-month-old infants. *Science*, **274**, 1926–1928.

Thompson, S.A., & Hopper, P.J. (2001). Transitivity, clause structure and argument structure: evidence from conversation. In P.J. Hopper (Ed.), *Frequency and the emergence of linguistic structure* (pp. 27–60). Amsterdam: John Benjamins.

Tomasello, M. (2000). Do young children have adult syntactic competence? *Cognition*, **74** (3), 209–253.

Tomasello, M. (2003). *Constructing a language*. Boston, MA: Harvard University Press.