

## **The Origin of Argument Structure in Infant Event Representations**

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When deaf children of hearing parents are not exposed to a language model, they invent their own communication systems using gestures (Goldin-Meadow, 1985). Such “home sign” systems have been shown to be rich in expressive power, and to exhibit many parallels to conventional languages including a primitive form of argument structure. When gesturing actions such as *giving*, home signers demonstrate that they are sensitive to the fact that giving entails three arguments: A giver, a recipient, and an object being given. This phenomenon suggests that the human conceptual system constructs event representations that possess argument-like structures independent of overt linguistic input. Understanding the nature of this development addresses fundamental issues of the relation between language and thought and their origins.

In a set of pioneering studies of the development of linguistic concepts in infancy, Golinkoff (1975) and Golinkoff & Kerr (1978) examined whether 14 to 24 month olds had general concepts of agent and patient, the fundamental elements of transitive structures in language. In studies employing looking time and heart-rate deceleration, they familiarized infants with filmed actions involving people pushing other people or pushing tables and chairs. On test trials, infants saw a new film in which there were reversals of roles and/or positions on the screen. There were effects of role switching in this paradigm although it is difficult to determine whether this implied the existence of semantic roles in infant representations.

These and other studies of infant linguistic knowledge (e.g., Golinkoff, Hirsch-Pasek & Gordon, 1987), suggest comprehension of linguistic structure in infants who are actually using language in some way, beginning at about 14 months of age. Questions about the conceptual origins of linguistic abilities, however, require that we look to a period before language is being learned in earnest prior to the end of the first year. To study the possible non-linguistic origins of verb-argument structure, we need a task that provides a reasonable non-linguistic conceptual analogue in the encoding of event structure.

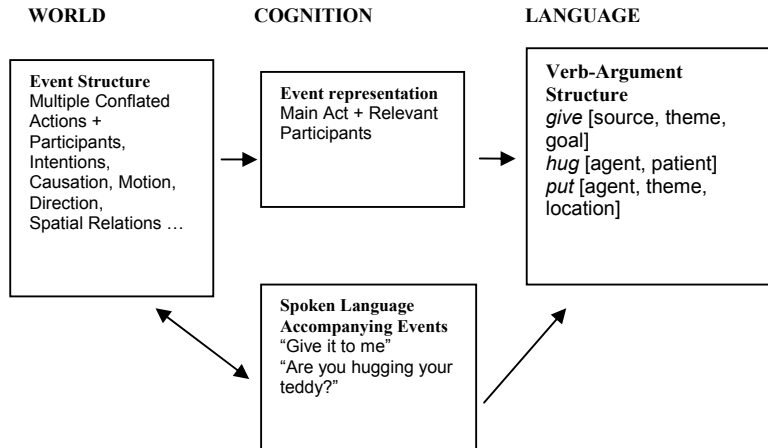
Any attempt to provide a one-to-one mapping between prelinguistic event structure and verb-argument structure is surely doomed to failure because of the fact that there is cross-linguistic variation in how any particular verb is expressed in terms of argument structure. What might be an argument in one language might be an adjunct in another. In addition,

a verb might be causative in one language, but non-causative in another and hence inherit a different valency. For example, in Korean, it is possible to say: *The clown laughed the boy* with two arguments instead of one in English. Instead, we must aim for a theory of how prelinguistic event structure might lay down the framework for a set of *candidate* arguments that are available for incorporation in the particular language being acquired.

How then might candidate arguments be distinguished from non-candidates in the everyday perception of events? Everyday events consist of goal-directed, intentional-causal actions of people or animals or the intentional actions of vehicles as they are controlled by people. There are mental acts and states such as seeing, knowing, learning, and loving which may reveal themselves through subtle or not-so subtle forms of behavior. There are accidental occurrences like things falling over, and there are acts of nature, like snow falling, which may have causal but not intentional structure. We live in a world where things happen and sometimes people make things happen, and often things happen for a reason, an intention, a goal. The world is rich in structure, yet it can be confusing to the unprepared. A robot that did not have some kind of specific programming would not be able to parse the events in the environment and be able to map those events onto the verb-argument structures of a natural language – let alone create its own language as home signers do. One has to see the world in a particular way, and infants must see the world in a particular way before they acquire language.

I assume that the relations between language, cognition and the world, look something like in Figure 1. Within this framework, what makes something a candidate argument in event structure is that it is RELEVANT to the event. This means roughly that it helps to define the event in some sense. If the element were not included in the event structure, the meaning of the event would change. For example, if we consider the three elements involved in the act of GIVING: The GIVER, the THING given, and the RECIPIENT, all of these elements are required for the action to be defined as one of GIVING. If there were no object or abstract entity (like “giving advice”) being transferred, then this would no longer be an act of GIVING. On the other hand, if one were carrying an object whilst HUGGING someone, deleting the object from the scene would not change the meaning of the event. While relevance may or may not work for defining ALL candidate arguments, it is a good starting point to consider whether preverbal infants distinguish between objects that are candidate arguments in an event structure and those that are not.

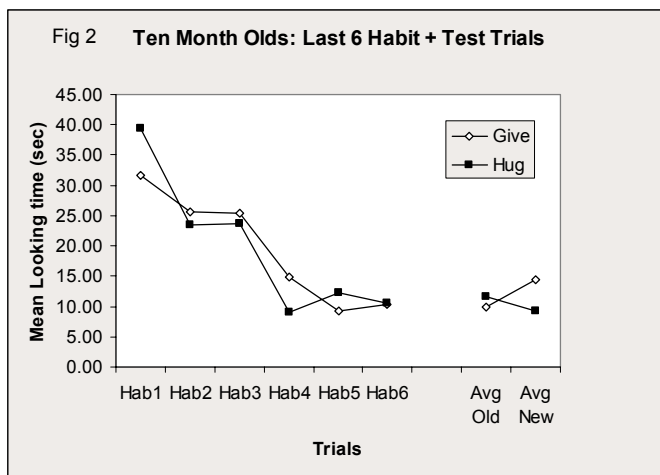
**Figure 1 Mapping relations between events and language in the acquisition of verb-argument structure**



**1. Experiments on event representation in infants**

**1.1 Experiment 1 GIVE vs. HUG**

In this experiment, 48 10 month olds were tested using a looking-time habituation paradigm. Infants saw a repeated presentation of a looped video of an action until looking time per trial decreased by 50%. They were then presented with 2 trials of the same video (OLD) and 2 trials of a different video (NEW) alternating over 4 test trials, with order varied between groups. Looking times to NEW versus OLD videos were compared to evaluate whether infants noticed the change in the event.



In this experiment, infants in the GIVE w/ condition saw a girl giving a toy to a boy, then on NEW test trials (GIVE w/o), the toy was no longer present. In the HUG w/ condition, infants saw a girl hugging a boy whilst carrying a toy, and without the toy (HUG w/o) on test. Looking times in Figure 1 show clear habituation to the training trials for all conditions. However, only in the GIVE condition was there a difference between NEW and OLD test trials ( $p=.02$ ).

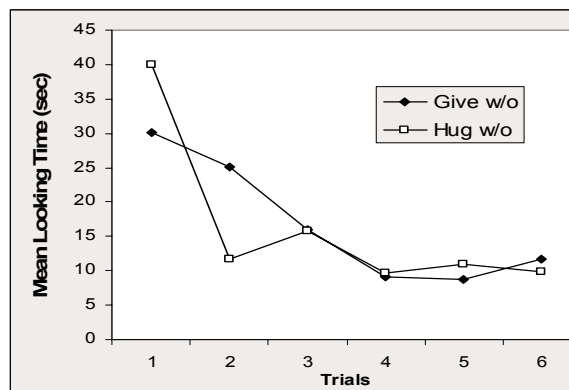
These data replicate previous studies reported in Scherf & Gordon (1998,2000) with altered testing parameters resulting in stronger effects. They suggest that infants at 10 months of age distinguish between elements in an event that are relevant to the event structure from those that are irrelevant. I suggest that this represents a difference in the way in which the TOY is represented within the argument structure. This provides at least *prima facie* evidence that event representations are differentiated in the right kind of way that could allow a seamless and transparent mapping onto verb-argument structure when language is acquired.

## 2. Are test videos just “odd”?

### 2.1 Experiment 2: GIVE w/o vs. HUG w/o

Unfortunately, *prima facie* evidence cannot always be taken at face value. One alternative interpretation of the data from this experiment is that infants found the GIVE w/o video just “odd” (people don’t normally give nothing) whereas the hugging video without the toy was not. If this were the case, then one would expect that there would be a difference in looking times to the two test videos independent of training. To examine this possibility, in Experiment 2, the GIVE w/o and HUG w/o test videos were presented in alternating trials to 24 10 month olds. These data showed no difference in looking times over the 12 trials (see Figure 3).

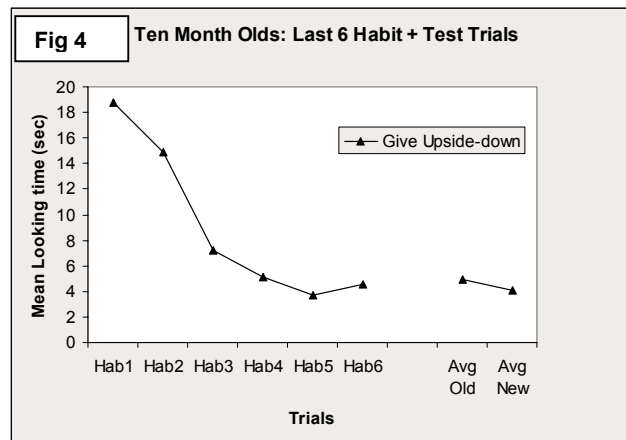
**Figure 3 Looking times to alternating test videos from Expt. 1**



### 3. Low-level perceptually-based explanations of effects

#### 3.1 Experiment 3 GIVE upside down

A second kind of alternative explanation for our results is that there might be some low-level cues in the stimuli that made the toy more salient in GIVE and less salient in HUG. Notice that this criticism is only pertinent if it doesn't boil down to some equivalent way of saying that the toy is *relevant* to the event in GIVE but not HUG. The pertinent counter claim is that the TOY has more *perceptual* salience in the GIVE video than in the HUG video – that there are some low-level visual properties that differ between the videos: the toy moves or rotates more in one video than the other; it covers more of the screen on one video etc. In Experiment 3, we examined this possibility by presenting 24 10-month-old infants with the same visual stimulus but devoid of meaning. We did this by presenting the GIVE video upside down. In this case, we found that, although infants showed habituation to the stimulus, they did not dishabituate when the toy disappeared. It could be argued that infants simply didn't pay attention to the TOY in the upside down condition, and hence did not dishabituate when it was withdrawn. In recent studies using remote eye tracking<sup>1</sup>, we have found, in fact, that looking at the toy was almost identical when the GIVE video was upright and inverted. In fact, it was almost impossible to tell the difference.



These data suggest that low level cues in the visual array attract infant attention to the TOY in the inverted condition, but they just don't make any sense of it in relation to the action. For this to happen, there must be a meaningful event occurring.

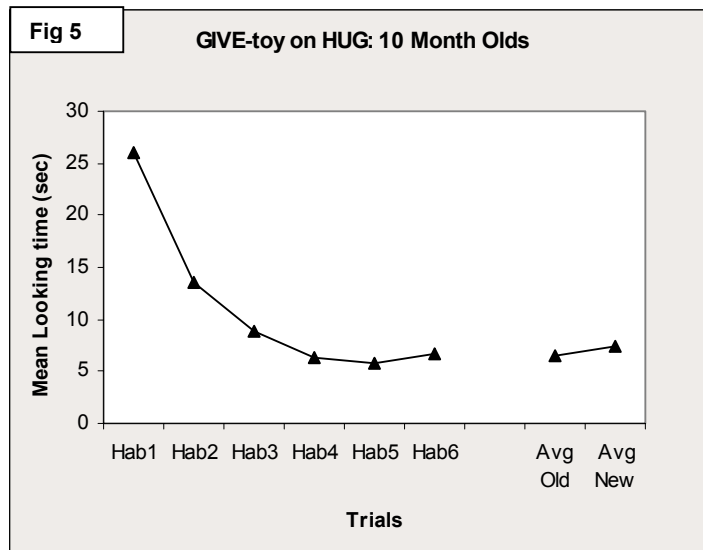
<sup>1</sup> Eye tracking videos mentioned in this paper can be viewed at

<http://www.tc.columbia.edu/faculty/pg328/files.htm>

#### 4. Controlling motion of the toy

##### 4.1 Experiment 4: Give-TOY on HUG

This experiment further examines whether infants' looking times might be due to low-level perceptual differences between the motion of the toy in the GIVE and HUG videos. To control the motion of the toy between videos, we developed a new video in which the toy from the GIVE video was isolated through video editing and was superimposed onto the HUG w/o video. Therefore, whatever purportedly salient properties of the toy in the GIVE video were, would be inherited in this video, but it would not be meaningful within the context of the background hugging action. Twenty four 10 month olds saw the video showing the GIVE-toy hovering in front of the HUG action. On NEW test trials, the toy was no longer present, and infants only saw the HUG w/o video. The toy in this video was extremely salient, and eye tracking studies showed that infants clearly tracked its movement. On test conditions, when the toy was removed, and infants just saw the HUG video, there was no recovery of looking time. The data in Fig. 5 show that infants do not dishabituate in this experiment. Even though floating toy was highly salient, this did not cause infants to look longer when it was gone. These results militate against any low-level account of the original data of this study.



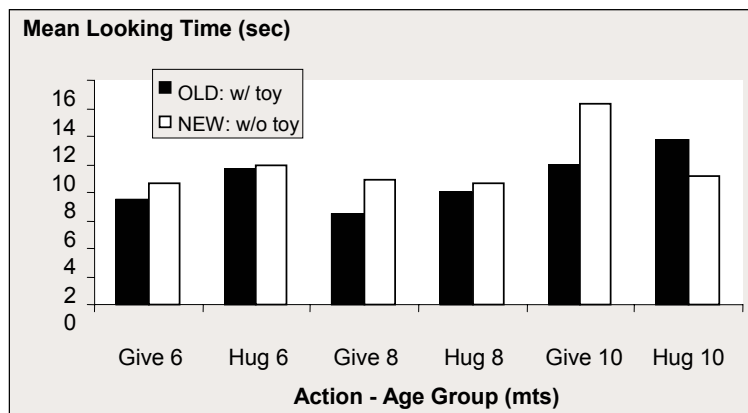
Despite the somewhat torturous path required to validate these results, it seems clear that they show that 10 month olds do focus on candidate arguments in an event structure like GIVE and that the habituation procedure is particularly sensitive to changes in event stimuli that result in changes in the meaning of that event. The question arises as to when infants begin to make sense of events such that this sets up a representation with

the potential to undergird the acquisition of verb-argument structure in language.

#### 4.2 Experiment 5: Developmental Changes in GIVE vs HUG

The same methods from Experiment 1 with GIVE and HUG were run on 24 six month olds, and 24 eight month olds. Results of these studies, shown in Fig. 6, were that the 8 month olds showed a marginal effect of toy removal on test for GIVE ( $p=.07$ ), and not for HUG. Six month olds, on the other hand, showed no such differences. It appears, then, that the significance of the transferred object in an event of GIVING is not appreciated until around 8 months of age.

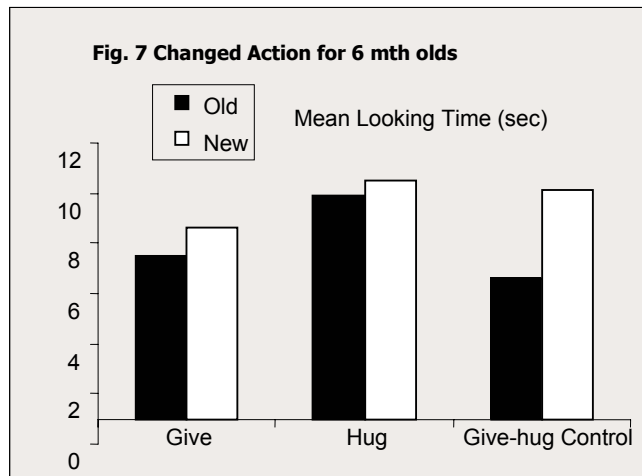
**Fig 6** Age-Related Changes in Looking Time on Test Trials



### 5. Can 6 month olds make sense of anything?

#### 5.1 Experiment 6: GIVE → HUG Control

To ensure that 6 month olds could actually perform on this task and provide usable data indicating that they could detect an event change. We need a condition in which infants could show increased looking time on test trials where there was a clear change in the meaning of the event. This was done by habituating 6 months to the GIVE w/ video and testing on the HUG w/ video – a complete change in the action. In this case, 6 month olds showed no difficulty in understanding the change in event, and showed increased looking to the NEW video over the OLD video ( $p<.05$ ). Figure 7 shows these data in the rightmost columns compared with the data from Expt. 5 for GIVE and HUG in isolation.



These results show that 6-month-olds can detect changes in events but appeared to be insensitive to changes caused by the removal of the toy in the GIVE video in Experiment 5. It would seem that removing the toy from the GIVE video affected meaning no more than removing the toy from the HUG video – that is, not at all. 6-month-olds do not seem to understand the idea of change of possession as an organizing event in their conceptual representation. This is quite interesting because a large proportion of 3-argument verbs encode some kinds of change of possession albeit with employing changes in the manner of transfer.

## 6. What you see is not necessarily what you get

### 6.1 Experiment 7: SHOW

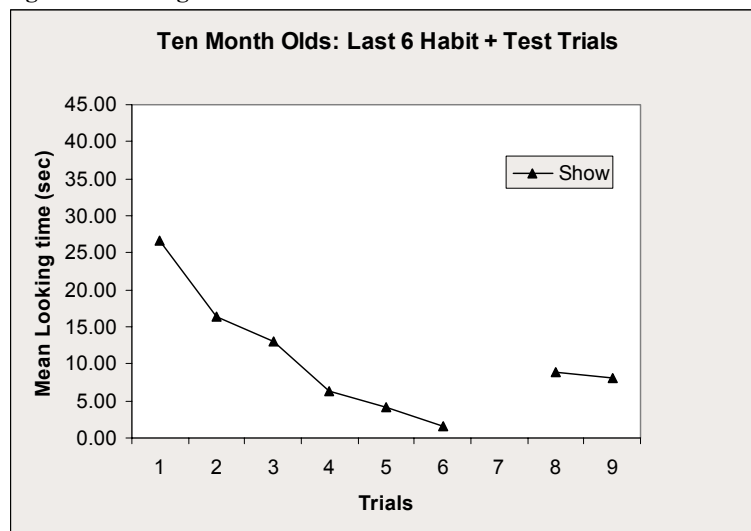
Results of the previous experiments suggest that 6-month-olds are unable to represent the event structure for GIVE in a way that would identify privileged elements like the toy as potential arguments. They don't seem to really understand the *point* of GIVING. Although it has been repeatedly shown that 10-month-olds have representations that privilege the transferred object for GIVE, should we therefore assume that 10-month-olds have 3-argument structures available quite generally, and that they are just waiting for language to come along and do its magic – transforming those argument structures into sentences? Well, no. What makes something significant to an infant depends on whether they understand the event that is occurring in front of them. So, what happens if we present an action to a 10-month-old that requires more advanced cognitive understanding of the event?

The final experiment of this paper tested twenty-four 10-month-olds with SHOW. In the video, the girl again walks up to the boy and this time shows him the toy rather than giving it to him. The boy wildly overacts with joy at seeing the toy and they back off to their respective sides. The action of SHOWING is interesting because to understand what is going on, one needs to have something like a theory of mind in which the idea of



transferring information between one person and another makes sense. This is quite a tall order for a 10 month old, given that many aspects of theory of mind may take several years to be adequately understood by children. When tested on the SHOW video, 10 month olds' looking time to the new SHOW w/o video (where the toy was removed) did not differ from the old SHOW w/ video (although there was recovery of looking time for both videos). Eye tracking studies with these stimuli illustrate that infants do track the toy on the SHOW w/ videos despite the fact that they do not increase looking time when the toy is removed. In other words, they see it, but they just don't get it.

**Figure 8 Looking times to SHOW videos**



### 7. Summary and Conclusions

The present set of studies has attempted to present a *prima facie* case that, for a 3 argument event involving GIVING, 10 month olds can distinguish between elements that are relevant to events and those that are irrelevant, in the case of HUGGING. This ability, it is claimed, puts infants in the driving seat, allowing them to acquire verb-argument structures in a relatively seamless fashion when language learning begins. Eight month olds show this ability somewhat less convincingly, and six month olds show it not at all (for GIVE) – even though they do appear to understand when an event changes in more radical ways such as changing from GIVING to HUGGING. The changes seen in looking times are not an artifact of more superficial changes in aspects of the video stimuli. Neither are they a simple reflection of what infants attend to. Eye tracking studies clearly show that infants can look at objects moving across the screen, but if they have no idea what it all means, then they will not show dishabituation to the disappearance of the object. Nor will they visually search for the object in its original location. Finally, experiments with

SHOW suggest that just having 3 arguments and being 10 months old is not enough. Even 10 month olds fail to develop event argument structures when the event itself is too complex and requires a more sophisticated conceptualization than is available at this age.

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