Language, Goals and the Selective Learner:

How Syntax Guides Infants’ Interpretation of Goal-Directed Events

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***Abstract Here***

“The trouble is that an observer who notices *everything* can learn *nothing*”

—Lila Gleitman

Humans are innately communicative beings, but how is it that we come to develop our capacities for language? Among the first theories to be proposed was a simple association mechanism by which learners heard the unfamiliar word in the presence of its referent, giving rise to seemingly intuitive word-to-world mapping between language and concept (Locke, 1690). However, a number of conceptual truths confound this proposal. First is the pure statistical and computational power required to properly match an unfamiliar word to an infinitely long list of possible referents (Quine, 1960). This account, which would be a slow, laborious and error-ridden process, does not align with the observed speed and accuracy with which young children acquire language (Carey, 1978). Additionally, this mechanism does not speak to how we come to acquire words for concepts that are abstract, unobservable, dynamic, or ones that necessarily co-exist (e.g. cars and tires, or bunnies and floppy ears).

In this way, the challenge of acquiring a language is an induction problem: a finite source of information (our limited exposure to a word) yields an infinite number of hypotheses (all of the possible referents to which a word may refer). As Steven Pinker (1994) points out, induction problems are often overcome by the presence of natural constraints on these possible hypotheses. By systematically reducing the number of plausible referents in a conceptual space, word-to-world mapping becomes more robust and efficient. Indeed, constraints of this kind have been found within the domain of noun learning (see Markman, 1991; Markman & Hutchinson, 1984; Markman & Wachtel, 1988), but to what extent do these principles extend to the conceptually more difficult task of verb learning?

*Selective Attention: A Moderate Theory of Syntactic Bootstrapping*

Syntactic bootstrapping, a term coined by Lila Gleitman (1990) in her book on language acquisition, is the verb-learning analogue to noun-learning biases. The principle claim of syntactic bootstrapping is that children use the structure of the sentence in which a novel verb appears to bootstrap its meaning (Gleitman, 1990). This reduces the number of possible concepts that may be considered as a word’s referent, and also explains how verbs to describe abstract or unobservable concepts are acquired. Importantly, this “database” of potential concepts is categorical, rather than probabilistic, meaning that less evidence is required to reliably and accurately map a word to a concept. Theoretically and anecdotally, Gleitman’s proposal seems to robustly account for both the patterns and the nuances of children’s language acquisition. However, her argument is not without its limitations.

A number of qualifications to Gleitman’s theory have been suggested (see Pinker, 1994, for the most direct critique), but perhaps none as fundamental as those calling into question the actual power and purpose of the subcategorization frames. Pinker (1994) argues that these syntactic structures are not actually encoding the true *meaning* of a word, as stronger interpretations of the syntactic bootstrapping theory would suggest. Instead, they are acting as a sort of “zoom lens” that helps the listener discern to what aspect or perspective of the event structure a verb is referring. Pinker believes, and Gleitman concedes, that some information is just not available in subcategorization frames, and needs to be gleaned through observation. Thus, if we wish to make sense of how subcategorization frames and observation systematically facilitate the acquisition of novel verbs, we must turn to research that explores to what aspects of event structure young language-learners are able to attend.

*Understanding Events in Infancy: Principles of Rationality*

Infants’ comprehension of the world around them is far from the “blooming, buzzing confusion” originally suggested by famed psychologist, William James (1890, pg. 488). Remarkably, even very young infants demonstrate adherence to a highly systematic schema of event interpretation. Amongst the most widespread and foundational components of this schema is their comprehension of—or, as some would suggest, obsession with—goals.

In his seminal paper, Andrew Meltzoff demonstrated that 18-month-olds would perform the *intended* action of an experimenter, both in conditions where the experimenter’s attempts were successful *and* when they were not (1995). This work demonstrated infants’ ability to infer the intentions of the adult experimenter, with focus given to the goal (i.e. successful outcome) of the action, rather than the means used, in vain or not, to achieve it. Further, Woodward (1998) found this same goal-fixation behavior in infants as young as six months. By this age, she claims, infants have a “mature understanding of goal-directed action,” and this helps them to attend to the most relevant aspects of an event (1998, pg. 1).

In light of this, the contemporary belief was that infants are acutely able to distinguish between goals and means (Meltzoff, 1998). However, unlike the focus given to how infants interpret goals, a lack of exploratory work left researchers with a markedly impoverished understanding of how infants conceptualize means. In fact, research at the time suggested a highly simplistic view: when infants were given the opportunity to imitate an event, they would exclusively imitate the means of the demonstrating actor with little variation or room for interpretation (Meltzoff, 1998). It wasn’t until Gergley and his colleagues (2002) published subsequent work on infants’ understanding of means that the true complexity of infants’ comprehension of goal-directed events was revealed.

In what came to be known as Gergley et al.’s (2002) rational actor imitation paradigm, 14-month-olds saw an experimenter achieve a goal (turning on a light box) by utilizing a novel means (leaning forward to touch her forehead against the light box). While all infants saw the same novel manner produce the same goal, the context of the events varied between the two conditions. In the *hands occupied* condition, the experimenter had her hands concealed underneath a blanket, which she was holding tightly around her shoulders. In the *hands free* condition, her hands were placed on the table to either side of the light box, clearly visible to the child, while the blanket was loosely draped around her shoulders.

What Gergley and his colleagues found was that imitation responses patterned differently between the two conditions—a surprising result given Meltzoff’s and others’ impoverished understanding of infants’ expectations about means. Infants in the *hands occupied* condition opted to use their hands more often than their heads when imitating the novel event. The researchers suggested that the infants were attributing the experimenter’s novel behavior to the fact that she had her hands unavailable to her, as they were holding the blanket around her shoulders, and thus had no other means but her head to achieve the goal. Given that the infants did, in fact, have use of their hands, they were more likely to make use of that more practical manner. In contrast, infants who saw the experimenter perform the novel head touch, even when her hands were clearly available to her, more closely imitated the novel means demonstrated. They were supposedly reasoning that, if the experimenter had the option to use her hands yet chose to use her head, there must be something important or essential about this novel choice, and thus, that proper imitation necessitates it (Gergley et al., 2002).

Infants are not only demonstrating expectations about goal-directedness, but about the means to achieve those goals by as early as 12-months-old (Schwier et al., 2006). When combined with previous theories on infants’ event comprehension, findings from rational actor imitation paradigms give rise to a more robust and accurate depiction of how infants interpret events as they unfold. First, it is known with relative certainty that infants expect humans (but not necessarily inanimate actors) to be goal-directed. Infants are also capable of deducing what means are most efficient to achieve the goal, and importantly, utilize that particular context’s unique constraints to inform their judgment. Lastly, once infants have developed a naïve theory about the most efficient means to achieve a goal in a specific context, they then expect actors around them to perform in accordance with this efficiency. These characteristics were confirmed in a study done by Phillips and Wellman (2005), who found that 12-month-olds were only surprised to see an experimenter use an indirect arm reach to grab a ball when the context made the manner novel—that is, when the experimenter could have used a direct reach, instead. When the situation was changed and a barrier was placed between the experimenter and the ball, the novel arm arc was no longer interesting to the infants, given their appraisal of the new context’s constraints (Phillips & Wellman, 2005).

Taken together, this evidence suggests that infants are able to systematically parse dynamic events into their component features, and further, that they are then able to use these complex understandings to inform both their judgments of present events, and their expectations about subsequent actions. The ability to attend to the various components of an event structure is analogous to the “zoom lens” mechanism suggested by a moderate interpretation of Gleitman’s (1990) theory of syntactic bootstrapping. In particular, the emergence of the goal-means distinction early in the development of event perception could suggest a similar mechanism within the realm of language. In combination, this would provide both the subcategorization frame and extralinguistic (i.e. observational) information infants require to constrain the infinite list of possible concepts to which a novel verb may refer.

*Linguistic Manifestations of the Goals-Means Distinction*

In linguistics, there are a number of dimensions upon which verbs may be classified. One of these distinctions divides an event structure on the basis of either goals or means, similarly to the relevant research on infants’ event perception. In what’s known as the manner versus outcome distinction, single verbs, as well as entire syntactic frames, encode information about either *how* something is done (in the case of manner verbs/phrases) or the *result* of the thing done (in the case of outcome verbs/phrases). On the word-level, take the following sentences:

1. Jane *wiped* the dirty table
2. Jane *cleaned* the dirty table

From sentence (1), we may infer what means are occurring during the event—that is, that there is “wiping” taking place—but there is nothing encoded in the verb itself that reveals the outcome of the event. This is to say that both of the following sentences are perfectly sensible:

1. Jane wiped the dirty table, *and then it was clean*
2. Jane wiped the dirty table, *but there was still food everywhere*

In both cases, the same means are used, yet result in a very different outcome. Compare this to the contrasting example of an outcome verb in sentence (2). Here, we can infer the end result that has occurred—namely, that the table is now clean—but we are none the wiser to how this goal was achieved; nothing in the verb’s meaning encodes whether the means involved using soap or a sponge or a power washer, etc.

The same distinction also applies on the structural level. Take the following subcategorization frames:

(5) Mark \_\_\_\_\_\_\_ *to* his neighbor

(6) Mark \_\_\_\_\_\_\_ his neighbor

Verbs that fit sensibly into the syntax of sentence (5) encode manners (e.g. *yelled, waved, sang*), while logical completions of sentence (6) encode outcomes (e.g. *hit, hugged, saw*). What becomes clear in these examples is the constraining power of the manner versus outcome syntactic distinction as a subcategorization frame. Importantly, manner and outcome verbs—and by extension, the syntactic frames into which they fit—are nearly always in complementary distribution (Rappaport Hovav & Levin, 2008). This added restriction means that this contrast is poised to be a particularly rich and reliable cue. What then follows is to explore whether children are sensitive to this cue in the same way that adults are, and if so, whether this linguistic information can modulate, or shift the “zoom lens” on their interpretation of extralinguistic events. According to Kline and Snedeker (2015), both of these claims are true by the time children reach two years of age.

In their study, all participants saw the experimenter perform a novel head touch in the *hands occupied* position, identical to the one featured in Gergley et al.’s (2002) rational actor imitation paradigm. This establishes a baseline response—namely, that without any other intervention, children should perform the more rational hand touch response when asked to imitate the novel event. The participants were then split into two language conditions: *manner* and *outcome*. In the *outcome* condition, children heard a novel verb within a goals-encoding syntactic frame (i.e. “I’m gonna *dax* my toy”). In the *manner* condition, children heard the same novel verb used within the context of a means-encoding sentence (i.e. “I’m gonna *dax to* my toy”). The experimenter introduced the novel phrase, performed the novel head touch, and again repeated the novel phrase to describe the action that had been performed (i.e. “Look! I *daxed (to)* my toy!”).After repeating this demonstration process twice, the experimenter prompted the children to *dax* (*to*) the toy (dependent upon condition). The measure of interest was children’s first contact with the toy.

When imitating the novel event, participants in the *outcome* condition performed proportionately more hand touches. This result is unsurprising, given that they received both syntactic and observational cues encoding the goal as the most important feature, thus privileging the more efficient means. In contrast, children in the *manner* condition performed the novel head touch more often, suggesting that the syntactic cue was salient enough to shift participants’ perspective toward the means, and pull them away from the more rational baseline response (Kline & Snedeker, 2015). 2-year-olds’ selective imitation of the feature of the event encoded in the syntactic frame used by the experimenter, even when this imitation was not the most rational means possible within the event’s context, demonstrates the use of the linguistic frame as a constraining mechanism that may guide attention to aspects of an event structure.

The present research attempts to extend this work to 18-month-olds. As we have seen, infants at this age have a rich understanding of rational action, but can these expectations be modulated by language in patterns similar those found in 2-year-olds? Exploring this would reveal two principle insights: first, to what extent young infants are sensitive to the manner versus outcome distinction; and second, if infants are capable of using the manner versus outcome distinction as a cue to shift their attention to the privileged feature (either means or goal) in their conceptualization of the event structure. From this, we may begin to chart out a developmental trajectory for this particular cognitive mechanism, and broaden our understanding of what subcategorization frames are useful to language-learners, when they become accessible to infants, and how exactly they facilitate word learning.

**Experiment 1**

To allow for a more robust analysis of the data, a 2 x 2 (hands x language) between-subjects design was used. Running all four possible conditions simultaneously meant that various patterns could be interpreted more holistically. For example, if participants in the *hands exposed* conditions performed more head-touches than those in the *hands occupied* conditions, this would support a successful replication of Gergley et al.’s (2002) finding that infants systematically use contextual cues to develop naïve theories of rational action. Further, if participants in the *manner* conditions performed more head-touches than those in the *outcome* conditions, this would support two conclusions: first, that the semantic difference between manner versus outcome is salient to infants in our target age range; and second, that this difference is a cue that guides infants’ interpretation of events as they see them occur in the world.

Taken together, these predictions give rise to a sort of cue gradient, in which infants in the *hands exposed + manner* condition are given the most head-touch eliciting cues, and are thus pulled farthest from the hand-touch baseline response. Infants in the *hands occupied* *+* *outcome* condition would then be situated on the opposite end of the spectrum, receiving the fewest head-touch eliciting cues, and consequently performing more hand-touches. Examining the pattern of results for infants in the two intermediary conditions, who received both head- and hand-touch eliciting cues, presents the opportunity to measure cue “strength” or “dominance” when conflicting cues are conveyed simultaneously.

As was the case for 2-year-olds in Kline and Snedeker’s (2015) study, participants’ first contact with the toy was recorded as a measurement of whether they sought to imitate the manner (head-touch) or outcome (hand-touch) of the demonstrated event. While 2-year-olds’ firsts responses proved to be significantly different between conditions, a majority of rational action studies conducted with infants 18-months-old or younger only found a significant difference in response patterns between conditions when participants were allowed to freely explore the toy, performing multiple action attempts (e.g. Kiraly, Csibra & Gergely, 2013). However, it could be the case that this difference between 2-year-olds and younger infants is attributable simply to the size, rather than the nature, of the effect. To explore this possibility more systematically, we introduced an exploration period characterized by the failure of the toy to activate upon first contact.

We predicted that, if participants used linguistic and observational cues to form expectations that privilege *how* the novel event is performed, it is of no consequence if their imitation does not result in the same outcome as when it was demonstrated by the experimenter. In short, so long as they have performed the novel head-touch, they have successfully imitated the novel event. We might then expect to see less interaction with or persistence in trying to activate the toy during exploration, as they already believed they had successfully performed the intended action (i.e. the head-touch). In contrast, if the language and hand cues cause participants to form expectations about the *result* of the novel event—namely, that the toy will light up when touched—then failure of the toy to activate may lead infants to explore the toy for longer, to utilize differing strategies (i.e. manners) to bring about the desired result, or perhaps to express more frustration relative to participants in the manner condition as a direct result of their perceived failure to imitate the novel event. Importantly, this prediction holds regardless of the means used during the first contact with the toy. In order to preserve this, the novel helicopter toy used in Kline and Snedeker (2015) needed to be refabricated.

With the original toy, a participant may roughly “succeed” at activating the helicopter by manually spinning its blades during a hand-touch. While this has the potential to positively reflect our predictions regarding the desires of infants in the outcome-focused conditions to imitate the most effective means to bring about the goal, it prevents our ability to more thoroughly evaluate these expectations by introducing a surprising context in which this goal is not achieved through these efficient means. For this reason, the helicopter was replaced with a clear plastic globe filled with spinning lights that could only be activated by a hidden button concealed on its handle. A large silver dome was also added, positioned opposite the globe on the top of the box surface. This feature was meant to focus infants’ imitation response to one local area, given their familiarity with acting upon buttons. Using this updated toy and the more robust experimental design, Experiment 1 was an attempt to test the extent to which language could shift 18-month-olds’ interpretations of rationality when observing a novel event.

**Method**

**Participants**

Participants were twenty 18-month-olds (range 17 months 3 days to 19 months 3 days; 11 girls). An additional seven infants were tested but not included in the final analyses due to refusal to interact with the toy at test (*n* = 5) or experimenter error (*n* = 2). All infants were recruited from a university database of interested families in the Cambridge area, and received a small toy and five dollars of travel compensation for participating.

**Materials**

The novel toy presented during the critical trial was a 12in x 4in x 10in box covered in green felt. A globe was situated a few inches away from a silver button on the box surface, and contained lights that would illuminate and spin upon activation (*figure X*). The globe’s handle was concealed within the box, and was wired to a button to facilitate hands-free operation of the spinning lights. A small camcorder was positioned facing directly perpendicular to the infant to record their interaction with the toy.

**Procedure**

Families were greeted upon arrival to the lab, where the experimenter engaged the child in interactive free play in the lobby. At this time, parents were given instructions on how to neutrally respond to their children during the exploration period, where the participants were allowed to freely interact with the toy. To reduce any potential for biases, parents were also asked to refrain from giving explicit guidance on how to operate the toy, and told instead to give vague feedback such as, “hmm…I don’t know!” or “what do you think?” Parents were also informed that they should avoid specifically directing their child’s attention to the toy, as a lack of interest would be an equally meaningful measure of engagement.

Then, when the infant appeared to be adequately comfortable socializing with the researcher, the family was escorted to a second room to begin the experiment. The testing room was a well-lit space that was empty except for two chairs, a table, and a curtain lining one of the sidewalls. The infant was placed in the parent’s lap and the pair sat directly across from the experimenter with the small table positioned in between them.

The study then began with a series of simple warm-up trials similar to the game Simon Says, in which a puppet, manipulated by the experimenter, would perform a simple action (e.g. clapping) and then encourage the infant to imitate the action as well. This activity was geared toward preparing the infants to engage in imitative play. At the end of the warm-up trials, the puppet was put away and the novel toy was introduced.

In both the *hands exposed* and *hands occupied* conditions, the experimenter exclaimed that she was cold, and proceeded to wrap herself up in a blanket made of blue fleece. In the *hands occupied* condition, the experimenter used one hand to hold the blanket tightly around her shoulders, and the other to surreptitiously operate the toy out of view of the infant via the wired button. In the *hands exposed* condition, the experimenter loosely draped the blanket over her shoulders, and while doing so, covertly attached the button to a small piece of Velcro located on the underside of the table. The experimenter could then operate the toy by simply raising her knees to compress the button against the table. Once the button was secured, she placed her hands palms-down to either side of the toy, clearly visible to the participant.

At this point, the critical sentence was introduced: either “Look! I’m going to *dax to* my toy!” in the *manner* condition or, “Look! I’m going to *dax* my toy!” in the *outcome* condition. This sentence was then followed by a demonstration the novel head touch event, which consisted of the experimenter leaning forward to touch the silver button on top of the toy with her head (*see* Gergley et al., 2002 *for review*) while simultaneously activating the toy’s lights. This created the illusion that physical contact with the silver button caused the lights inside the globe to turn on and spin (see figure X, grid of what conditions looked like).

After performing the action, the experimenter repeated the critical sentence to describe the event that occurred (e.g. “Look! I *daxed(to)* my toy!). This procedure was then repeated a second time, such that by the end of the demonstration period, each participant heard the critical sentence a total of four times. The sentence was introduced one final time when the toy was placed within the infants’ reach, and the experimenter prompted the child to *dax (to)* the toy. When the participants made first contact with the toy, the experimenter did not activate the globe as in the demonstration, but instead simply responded with the neutral, yet enthusiastic reply, “Okay! Now you can play.” This then initiated the exploration period.

During the exploration period, the experimenter told the children “they could play” or that “it was their turn” before walking off to another corner of the room and shuffling papers to look preoccupied. The main purpose of this portion of the study was to investigate infants’ persistence when the toy failed to operate. After 60 seconds, or sooner if the child had begun to fuss, the experimenter returned to the table and encouraged the child to make one more attempt at contact with the toy, which was rewarded by activation of the lights and very enthusiastic praise. Participants were allowed to play with the now-functioning toy for a little while longer before the session was ended, and the families were debriefed and thanked.

**Coding**

All sessions were videotaped in order to accurately assess each participant’s first contact with the toy. Videos were viewed by the experimenter directly after the session, and coded as “hand touch,” “head touch,” “N/A” (for no response) or “fuss out,” when a participant was unable to complete the experiment. Any contact made exclusively by a hand (i.e. pressing with palm) or finger (i.e. poking) was coded as a hand-touch. For the purposes of this particular paradigm, a head touch was inclusive of lips, cheeks, chins, and the like, in addition to the more straightforward forehead contact. Given 18-month-olds’ limited motor coordination, head touches preceded by the use of the hands as a helping agent (e.g. lifting the toy to their head) were considered valid head touches. Both anecdotal evidence and the findings from previous research (e.g. Kiraly, Csibra & Gergely, 2013; Kline & Snedeker, 2015) suggested that manifestation of infants’ imitation attempts at this age are extremely varied, and thus the more inclusive criteria for a head touch was designed to capture whether the children recognized the use of a novel body part, and sought to imitate that novelty, as well.

**Results**

The frequency of each first response type, either head-touch or hand-touch, is presented in Figure X. Contrary to our predictions, all but one infant performed the hand-touch baseline response, regardless of condition. Consequently, participants’ behaviors during the exploration period were not coded as part of this analysis.

Exploratory descriptive analyses of our sample revealed that there were no significant differences in the average age of girls and boys (*t* = 0.28, *p* = 0.78) or between the conditions (*t* = -1.64, *p* = 0.13). Further analyses also suggested that participants’ vocabulary scores were consistent between conditions (*F* = 0.26, *p* = 0.76) and also between genders (*t* = 0.50, *p* = 0.62). However, there was a correlation between participant age and vocabulary score, *r*(19) = 0.46, *p* = 0.05.

**Discussion**

Experiment 1 was designed to test the relationship between the structures in which a novel verb is presented, and infants’ rationality judgments about the novel event the verb was meant to describe. If infants used both language and action cues to inform their interpretation of the event, we predicted that participants across conditions would form different judgments about the experimenter’s rationality. Infants in the *outcome + hands occupied* condition would use these language and action cues to contextually justify the demonstrator’s novel means, but would nevertheless opt to use the more efficient hand-touch when imitating the event themselves. However, infants in the *manner + hands exposed* condition would use these cues to infer that the demonstrator’s novel means were essential to the event itself, and thus seek to imitate that novelty, as well.

Instead, we found that virtually all participants performed a hand-touch imitation. Given the homogeneity of response type, the exploration portion of the experiment was not coded for inclusion in the final analyses. Without producing virtually any head-touch responses, we cannot be certain whether patterns found using this paradigm are a true representation of infants’ cognitive and linguistic abilities, or simply the result of an uninformative methodological flaw. In either case, it is unlikely that this unexpected finding can be attributed to any sampling errors or characteristics of our participants. Exploratory descriptive analyses showed there to be no relationship between participants’ age, gender or vocabulary size and the condition they were placed into. The only observed correlation—between age and vocabulary size—is neither surprising nor consequential. We would surely expect older infants to have larger vocabularies, and this effect is neutralized by the fact that each condition had a similar distribution of ages, and therefore also of vocabulary sizes.

Amongst the possibilities that remained was the claim that our paradigm was, in fact, sensitive to the effects we set out to measure, and 18-month-olds’ desire to use the more efficient means is an accurate reflection of their prioritization of goals. This would, however stand in opposition to a large body of literature that characterizes the sensitivity of infants’ event perception to rich sources of contextual information. Our findings were therefore more likely to be the result of some form of procedural or material limitation. Accounting for these shortcomings was the focus of Experiment 2.

**Experiment 2**

The same 2 x 2 (hands x language) design used in the first experiment was also used for Experiment 2. However, the materials and procedure of the second experiment were modified with the goal of eliciting head-touches in addition to the previously recorded hand-touches. If our methods could be changed such that we are able to elicit both response types, this would suggest that, within the context of our paradigm, there is some circumstance in which infants are willing to perform a goal-directed action using novel means. Only then would we be able to draw conclusions as to what exactly about these circumstances cause infants to deem the otherwise indirect action as being necessary.

To that end, the first consideration made was in regards to potential physical constraints within the paradigm. Perhaps it is the case that 18-month-olds are physically unable to perform the motor functions necessary to complete a head-touch. This action requires core strength, upper body strength, and the skilled coordination of the two. However, previous research, including Gergley et al.’s (2002) study, has featured infants as young as 14-months-old successfully completing head-touches (see also Paulus, Hunnius, Vissers & Bekkering, 2011). This would suggest that our participants have the motor skills necessary to perform a head-touch, and thus the novel lean was kept as our indirect manner.

The next consideration made was with regards to the toy, itself. After thorough review of previous rational actor imitation paradigm studies that used any remotely similar type of light box stimulus, two key alterations became evidently necessary. First was to change the actual dimensions of the toy. Most toys used in the other studies were mounted on boxes ranging in height from a mere 4.5 to 6cm, markedly shorter than our 10in tall toy. Lowering the toy not only puts it within a physical range that is more comfortable for the infants, but also makes demonstrating the novel head-touch action far more salient, by requiring a full bend at the waist by the experimenter, rather than the simple head tilt required to reach the taller toy.

The second change to the toy streamlined the perceived relationship between the novel head-touch and the activation of the toy. To accurately recognize the novel event using the original stimulus, the infant must necessarily understand a relatively complex causal model. They must interpret that the experimenter’s acting on one side of the toy (the button) causes an effect in a visually distinct entity located on the opposite side (the globe). However, evidence from Experiment 1 suggests that this causal link may have been too opaque for 18-month-olds, given that over half (55%) of participants in the first experiment made contact with the globe, rather than the button, as their first imitation response (*figure X*). Thus, in Experiment 2, the button was removed, and the experimenter instead acted directly upon the globe, which was centered in the toy. This modification reduces the complexity of the action, while still providing a focused location toward which infants may direct their imitation response.

In addition to changes made to the toy, a longer, more effective warm-up period was implemented in Experiment 2. The added emphasis on ensuring all participants were sufficiently comfortable before the start of the critical trial served two functions. The first was to minimize the number of tested infants who became too fussy or uninterested in completing the trial, and would consequently be ineligible for inclusion in the final sample and analyses. The second function was more directly related to the goal and hypotheses of Experiment 2. A participant’s comfort and willingness to engage may have a direct effect on their response type, insofar as performing a head-touch requires the infants to physically separate from their parent. If a child is feeling somewhat unsettled in the situation, they may seek to remain in physical contact with their parent, and opt to perform a hand-touch, which they can complete while still securely attached to mom or dad. Thus, if we want to ensure that our paradigm is capable of eliciting head-touches, we needed to create an environment in which participants were both physically able and emotionally willing to perform the novel action.

Participants’ first responses were coded according to the criteria set forth in Experiment 1. An additional coding scheme was devised for use in Experiment 2 to more systematically parse the full range of participants’ exploratory behaviors. This coding scheme was organized hierarchically, based on the level of detail encoded within the data point or interval. At the two coarsest levels, videos were coded for the durations of time infants were engaging with the toy, and intentionally making physical contact with the toy. While these measures captured broad approximations of infants’ behaviors, they were crucial in determining the validity of our prediction that infants who had formed expectations specifically regarding the *outcome* of the event would be more persistent in turning on the toy when it failed to operate (i.e. engage more with the toy and/or perform more intentional body actions).

The next level of measurement captured individual instances of hand- or head-touches. These annotations were meant to be a detailed behavioral record for each participant that specified the number and kind of actions performed. This would allow us to measure the degree to which a participant’s condition is able to account for the variations in response patterns. The duration of each segment of the trial—warm-up, demonstration, first response, exploration and total trial length—was recorded as well, for the purposes of exploratory descriptive analyses.

Using this updated coding schema and toy, Experiment 2 was an attempt to (1) confirm that head-touches could be elicited using this particular paradigm; and (2) test whether hand condition, language condition or some interaction between the two could systematically account for the variance in participants’ imitation response patterns.

**Method**

**Participants**

Participants were forty-five 18-month-olds (range 17 months 4 days to 18 months 29 days; 20 girls). An additional four infants were tested but not included in the final analyses due to inability to complete the experiment (*n* = 3) or parental interference (*n* = 1). All infants were recruited from a university database of interested families in the Cambridge area, and received a small toy and five dollars of travel compensation for participating.

**Materials**

The novel toy presented during the critical trail was a 12in x 10in x 3in box covered in green felt. The globe and its handle were laid flat within the shallow box, such that the globe was partially protruding from the box’s surface (*figure X*). This created the illusion that the toy was a fuzzy green box with a button-like half-dome of lights situated in the center. A thin yellow ring made of construction paper was placed around the circumference of the globe, both to draw the infants’ attention to the globe and to make it more visually appealing. This toy was wired similarly to the one originally used in Experiment 1 in that the handle was connected to insulated wires leading to a button that could be operated in both the *hands exposed* and *hands occupied* conditions.

The lights in the testing room were slightly dimmed to increase the salience of the toy’s activation, and a small camcorder was positioned facing directly perpendicular to the participant to record their interaction with the toy.

**Procedure**

Families were greeted upon arrival to the lab. As in Experiment 1, the experimenter engaged the infant in interactive free play in the lobby while giving parents instructions on how to neutrally respond to their child during the exploration period of the study. Given that a lack of interest was a meaningful measure of engagement, parents were also reminded not to specifically direct their child’s attention to the toy, and to only reposition the toy in front of their child if the infant was making a clear indication of their desire to reach the toy in the event that it had accidentally fallen off or been pushed to the far side of the table. Once all forms were completed, the families were escorted to the testing room for an extended warm-up period.

Unlike in Experiment 1, a number of toys were displayed on the table at the start of the experiment. These included several small stuffed animals, a set of colored building blocks, and a textured red ball. The experimenter engaged in free play with the infant using these toys as a means to acclimate them to the unfamiliar room, as well as to further familiarize them with the experimenter. Toward the end of the free play, attempts were made to have the infant interact with the experimenter directly, by passing the ball back and forth across the table. This passing game was also a seamless way to introduce the puppet, who then began passing the ball to the infant. The ball was put away once the experimenter felt that the participant was sufficiently familiar with both her and the puppet, at which point the Simon-Says-like warm-up task from Experiment 1 was initiated.

In contrast to the first experiment, parents in Experiment 2 were instructed to participate in the warm-up game if their child was particularly shy or reluctant to engage. This was done, for example, by saying, “Hmm, I think mommy/daddy knows how to clap. Let’s all clap! Look! We’re all clapping!” The puppet was put away at the end of the warm-up trials before the novel toy was introduced and demonstrated by the experimenter exactly as it had been in Experiment 1.

Further following the original procedure, the exploration period began after the infant made first contact with the toy, to which the experimenter responded with the neutral, yet enthusiastic reply, “Okay! Now you can play.” After the duration of the exploration period, the experimenter returned to the table and activated the toy, enthusiastically praising the infant. The session was then ended, and families were debriefed and thanked for participating.

**Coding**

All sessions were videotaped in order to accurately assess each participant’s interactions with the toy. The experimenter coded first contact with the toy live during each session. Using the same criteria as in Experiment 1, first contact was labeled as either a “hand-touch,” “head-touch,” “N/A” (for no response), or “fuss out,” when a participant was unable to complete the experiment. This and all other behavioral measures were catalogued using the video annotation tool VCode, which allowed us to track both single-point and duration events during the trials (*figure X*).

The duration of each major segment of the trial as recorded in the first round of VCode annotation. These segments included the total trial length, warm-up period duration, novel action demonstration duration, the first response window, and the length of the exploration period. The first response window and exploration period were coded a second time, now indicating both the onset and type of the first response, as well as all other individual instances of head- or hand-touches. After reviewing a sampling of the trial videos, a half-second time delay appeared to be a consistent quantification of the separation between hand-touch attempts. Accordingly, for any hand contact made during the exploration period to be coded as a proper hand-touch, there must have been a half-second delay between its onset and the offset of any hand contact that preceded it.

In the final phase of coding, the durations of an additional set of measures were recorded. First was each participant’s *engagement*, which characterized any combination of (1) looking at the toy; (2) touching the toy; or (3) discussing the toy in some capacity (e.g. talking about the toy directly, asking for a parent’s help to fix it, etc.). The second measure was a slightly more specific record of *engagement* during the exploration period. These annotations, labeled *intentional body actions* (IBAs), captured intervals in which the participant was (1) making physical contact with the toy; and (2) looking at the toy *at the onset* (but not necessarily for all) of the contact period.

**Results**

(roughest of the rough outlines for now; will attempt to have something polished before 5pm today!)

1. First Response
   1. Data say X
   2. Brief Y/N – does that align with hypothesis?
   3. Descriptives
2. Exploration (response type)
   1. Data say X
   2. Brief Y/N – does that align with hypothesis?
   3. Descriptives
3. Exploration (engagement/IBA)
   1. Data say X
   2. Brief Y/N – does that align with hypothesis?
   3. Descriptives
4. Other descriptives

Marginally intelligent thoughts to occupy this space in the coming days ☺

**Discussion**

1. Reminder: what we expected, what we found
2. Coding scheme: strengths & weaknesses
   1. The original idea: hierarchy to capture multiple levels of interactions
   2. BUT no trends either in line with OR strongly against our hyp
3. Paradigm: strengths & weaknesses
   1. We got head touches, yay!
   2. Remaining possible limitations
      1. Maybe hands occ isn’t convincing enough / not natural
         1. Suggestions
      2. Other?

**General Discussion**

*Now looking at both sets of results*

* 1. Theory: strengths & weaknesses
     1. Contextualizing our results: reminder of why we had reason to believe the effect might exist
     2. Gergley’s failure, too...
        1. WHY: 18mos & event cognition
        2. WHY: 18mos & language

1. Other smart things