Repetition in infant-directed action depends on the goal structure of the object

Evidence for statistical regularities

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Adults automatically adjust their speech and actions in a way that may facilitate infants' processing (e.g., Brand, Baldwin, & Ashburn, 2002). This research examined whether mothers' use of repetition for infants depended on whether the object being demonstrated required a series of actions in sequence in order to reach a salient goal (called an "enabling" sequence). Mothers (n = 39) demonstrated six objects, three with an enabling sequence and three with an arbitrary sequence, to their 6- to 8- or 11- to 13-month-olds. As predicted, in demonstrations of objects with an enabling sequence, mothers were more likely to repeat *series* of actions, whereas for those without such structure, mothers were more likely to repeat *individual units* of action. This may or may not have been deliberately pedagogical on mothers' part, but nevertheless indicates another way in which input to infants is richly patterned to support their learning.

Keywords: infant-directed action or motionese, statistical learning, repetition, pedagogy

The highly structured nature of human behavior provides important opportunities for infants to learn about the world (Baldwin & Baird, 1999; Safran, Aslin, & Newport, 1996). In addition, adults automatically adjust their speech and actions in such a way that infants may find them easier to process (e.g., Brand, Baldwin, & Ashburn, 2002). The current research further examined the structure of actions in object demonstrations to infants. Specifically, we sought to determine whether mothers use different patterns of repetition depending on whether or not a series of actions must be performed in sequence to reach a salient goal (a so-called "enabling" sequence; Bauer, 1992).

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Children possess a sophisticated understanding of the actions of others from quite early on. For example, seminal studies by Woodward (1998, 2009) indicate that by as early as 5 months, infants treat reaches by human hands as directed at a particular goal, rather than as meaningless trajectories through space. Infants show a tendency to imitate the actions of others from birth (Meltzoff & Moore, 1977, 1983), and by the second half of the first year, are capable of imitating novel actions on objects (Meltzoff, 2007; Woodward, 2009). Despite this early sophistication, infants' skills in interacting with people and objects also undergo protracted development across the first few years of life (e.g., Carpenter, Nagel, & Tomasello, 1998; Sodian & Thoermer, 2004).

One mechanism supporting infants' learning may be their ability to process patterns in their environment. When there are statistical regularities in the input, infants seem to pick them up effortlessly. For example, eight-month-old infants can use the statistical regularities in speech, such as the probability of a certain phoneme being followed by another phoneme, to parse apart the speech stream into coherent units (Saffran et al., 1996). These abilities are not limited to the auditory realm; Kirkham, Slemmer, & Johnson (2002) found that babies can recognize similar patterns in a set of visual symbols.

Possibly as a way of enhancing or guiding infants' processing of patterns, adults modify their behavior when interacting with infants. It has been suggested recently that many of these modifications comprise pedagogical cues that specifically indicate a teaching-learning scenario, and that the very same cues that come naturally to adults — e.g., making eye contact, calling the child's name — trigger in the child enhanced attention and generalization of new information (Csibra & Gergely, 2006; Gergely & Csibra, 2005). Additionally, aspects of these modifications may enhance the statistical patterns inherent in natural behavior. One such cue is known as infant-directed speech, or "motherese". Infants prefer this type of speech (Cooper, Abraham, Berman, & Staska, 1997; Fernald, 1985) and it appears to aid them in segmenting and ultimately understanding speech (Fisher & Tokura, 1996; Ma et al., 2009; Thiessen, Hill, & Saffran, 2005).

Human action is another domain in which statistical patterns, specifically the transitional probabilities between units, have the potential to help people segment the input stream. Recent work by Baldwin and colleagues (Baldwin, Andersson, Saffran, & Meyer, 2008; see also Swallow & Zacks, 2008) documented that, after twenty minutes of exposure to a series of arbitrarily-ordered motions, adults could recognize which three-motion sequences had been repeated during the exposure and which had not. Baldwin et al. argue that although adults likely make use of top-down processes when dividing the action stream into meaningful units (e.g., by knowing likely goals of many actions), their work demonstrates that when *only* bottom-up information is present, adults can use this to segment the action stream.

One could hypothesize that for infants, who likely depend heavily on bottom-up information, the statistical patterns in the action stream may well provide important early clues to segmenting and ultimately making sense of the action stream.

As with speech, adults make modifications in their *actions* toward infants, some of which might increase the visibility of these statistical patterns. Infant-directed action, or "motionese", is specialized behavior involving a larger range of motion, greater proximity, more enthusiasm, greater simplification, more repetition, and more interactiveness — including increased eye gaze and exchanges of the object — than adult-directed action (Brand et al., 2002; Brand et al., 2007).

Motionese is both distinct from, and related to, the idea of 'gesture' as it is often defined. According to Kendon (2004), gesture may be best defined as actions that "have the features of manifest deliberate expressiveness" (15). Clearly, motionese falls under this broad definition. Typically, however, studies of gesture focus primarily on gesture's relationship to language (Goldin-Meadow, 2006; McNeill, 2000) and studies of infant-directed gesture usually examine gesture's ability to support the language development of infant listener (Iverson, Capirci, Longobardi, & Caselli, 1999; McGregor, Rohlfing, Bean, & Marschner, 2008). We suspect that motionese, on the other hand, has the potential to support infants' learning about actions *per se*, and thus to provide a bootstrap to the mental states and intentions that underlie them (Meltzoff, 2005). Some aspects of infant-directed communication clearly fall under the purview of standard deictic or iconic gestures, such as when mothers point at a button before pushing it, or mimic the appropriate movements for their infants when infants are in possession of the object. However, the central features of motionese have a different flavor: one of "action pedagogy" (Baldwin, Loucks, & Sabbagh, 2008; Csibra & Gergely, 2009), in which actions are performed with the dual intentions of achieving some goal state (e.g., opening a key safe) *and* teaching someone else about how to achieve that goal state. Despite the distinctions between gesture and motionese, if the current research can shed light on how interlocutors mark their actions as intentional or communicative, or on what infants might learn from such actions, then it is clearly relevant to the study of gesture more broadly. Understanding the nature of the modifications in movement that are characteristic of motionese and the role this plays in the way infants come to perceive human action will be important for the question of how 'gestures' come to be recognized as intentional actions.

Motionese features, as a group, are hypothesized to play several roles. First, these features may garner infant attention. In particular, larger, closer actions likely cater to infants' immature attention systems by making the actions more physically salient than other movements in the child's environment. In fact, motionese may function pedagogically to signal to the infant that something is being taught (Gergely & Csibra, 2005). In support of this claim, infants prefer to look at motionese demonstrations relative to adult-directed demonstrations of the same objects and actions (Brand & Shallcross, 2007). Another hypothesized role is to communicate about the function of the action, perhaps by exaggerating related emotional expressions, or by making important aspects of the action larger or more salient than non-crucial portions. For example, a parent demonstrating how to screw off a lid might exaggerate the "effort" conveyed in her face and posture when beginning the turning process, and might offer a bright, celebratory, mock-surprise face after lifting the lid off. A fourth potential role of motionese is to highlight the boundaries of action units, to help enhance infants' abilities to find patterns in the flow of movement. Our examination of the repetition patterns in motionese an attempt to learn more about this last potential role.

Two important features of motionese which may relate to its boundary-marking function are simplification and repetition. In Brand et al. (2002), simplification was defined as "small, simple units of action" rather than "complex *combinations* of many actions" (italics added). Based on this definition, the prediction is that when mothers demonstrate multiple action units on a given object, they would only show one kind of action at a time, separating action types from each other by repeating one action unit alone, or with a long pause or an offer of a turn to the partner. In Brand et al. (2007), we investigated one of these techniques for simplification: we measured the number of distinct action types mothers enacted during each turn (i.e., before handing the object to the partner). We found that mothers tended to demonstrate only one or two different types of action unit before handing the object over for infants; while for adults, they demonstrated an average of three. Thus, there appeared to be support for mothers' use of object exchanges as a way to segment actions.

As can be seen above, repetition and simplification might have a special, synergistic relationship to one another. Specifically, repeating a given portion of an action stream before moving on to another may serve a simplification function. As Avrahami & Kareev (1994) and Baldwin et al. (2008) have demonstrated, repeating distinct portions of an action stream highlights that portion as a unit with coherence apart from any other portion of the stream. In order to *simplify*, it was thought that mothers would *repeat* the smallest coherent units (such as twisting a lid to remove it). Consequently, in the original coding of repetitiveness, if *sequences* of actions were repeated rather than individual *units*, it was not considered as repetitive (Brand et al., 2002).

Despite this preliminary definition of repetition, we now hypothesize that the kind of repetition that is most useful to infants is likely to depend on the goal structure of the objects being used. Repetition that simplifies and highlights individual units may be useful if individual units of action are all that need to be taught. However, the same type of repetition might put infants at a disadvantage if what they need to learn are in fact *sequences* of actions. For example, imagine opening a key safe with a combination lid in order to fetch the key inside. (For an illustration, see Table 1: Lock Box.) To do this, it would be necessary to press some buttons in combination (A), slide the latch (B), and lift the lid (C). This has been called an "enabling" sequence (Bauer, 1992). The previous conception of repetitiveness would have labeled repetition of units (AA, BB, CC) as more repetitive than repetition of sequences (ABC, ABC). However, when several steps must be performed in sequence to achieve a desired end goal, then one might expect demonstrators to produce repetitions of entire sequences rather than individual units. Although on the face of it, repeated sequences may tax fragile memory and attention systems and make the action more difficult to parse, they may in fact support learning about the necessary flow of events.

Preliminary evidence for this possibility comes from Myhr (2003). In this study, young children were presented with six object demonstrations, each containing several actions on the object. For each child, three objects were demonstrated in an infant-directed style, and three in an adult-directed style. Drawing on the prior conception of repetitiveness in motionese (Brand et al., 2002), infant-directed demonstrations repeated the actions individually (e.g., AA, BB, CC) while adult-directed demonstrations repeated the entire sequence (e.g., ABC, ABC). For most of the objects, infants were more successful at imitation when the demonstration repeated actions (AA, BB, CC) rather than sequences, which is what one would predict with actions in an arbitrary rather than an enabling sequence. However, one object — a toy train which could be made to roll forward and play music — overwhelmingly resulted in better imitation when demonstrated with sequential action (ABC, ABC), even as part of an overall adult-directed demonstration (i.e., with smaller movements, less eye contact, and so on). Upon further examination of this object, we realized it fundamentally differed from the others in the extent to which a distinct sequence of actions was causally necessary in order to achieve the salient goal (the music and motion). That is, unlike the other objects, it had an enabling-sequence structure: to start the music and motion, it was necessary to *first* construct a platform, *then* place an animal on the platform, and *then* press down on the animal to activate a button underneath it. Thus, the goal structure of the object may have determined the type of repetition best suited for instruction about that object.

To summarize, the current study is an attempt to further characterize mothers' repetitions during object demonstration for their infants. Although prior work had deemed repetition of individual units the most "infant-directed," we now think that repetition will depend on whether or not the object has a sequence-goal structure. A preliminary study is consistent with the possibility that infants learn best when the demonstration style fits the structure of the object (Myhr, 2003).

Thus, in the current work, we predicted that mothers would vary their repetition patterns depending on the goal structure of the object being demonstrated. To test this, we asked mothers to demonstrate six objects to their infants — three of which have an enabling-sequence structure, and three of which have an arbitrary-sequence structure. To be clear, actions on both types of objects can physically be performed in any order, but those in the first group must be performed in a particular order *if* the salient goal is to be achieved. We then measured the transitional probabilities from one action to the next, predicting that mothers would use more repetitions of sequences when demonstrating objects with an enabling-sequence structure, and more repetitions of single actions when demonstrating objects with an arbitrary-sequence structure. In other words, for enabling-sequence objects, we predicted that an action A will most likely be followed by B, which will most likely be followed by C, and so on. For arbitrary-sequence objects, we predicted that an action A would often be followed by itself, rather than by actions B, C, or D. These patterns can be examined through transitional probabilities, through a comparison of the total number of completed sequences (ABC) in each demonstration, and through the proportion of two-unit series which are repetitions (e.g., AA) versus non-repetitions (e.g., AB or AC).

Because prior research on infant-directed input indicates that parents often modify the input according to the age of the infant (e.g., Fernald, 1985), we included two age groups of infants in the current study. For example, Gogate, Bahrick, and Watson (2000) found that mothers were more likely to utilize temporal synchrony and object motion when teaching prelexical (5- to 8-month-old) infants as compared to older age groups. Brand et al. (2007) also found some age differences in motionese itself for 6- to 8- versus 11- to 13-month olds. Specifically, mothers offered younger infants longer continuous bouts of eye gaze, and fewer exchanges of the object, than older infants. Relevant to the current investigation of repetition and simplification, however, there was no age difference in the simplification variable: mothers offered the same number of types of action per turn for both groups. In the current study, therefore, we included infants from both 6- to 8- and 11- to 13-months, but forwarded no hypotheses regarding age differences in the use of repetition of units versus sequences.

Method

Participants

Participants used in the final analyses were 39 mothers and their typically-developing infants aged 6–8 months ($N = 15$, 6 girls, $M = 6;30$) and 11–13 months

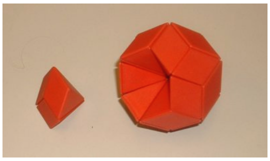
($N = 24$, 13 girls, $M = 12;7$) from a large metropolitan area in the Pacific Northwest. Participants were identified through a commercial mailing list or through online advertising, and were contacted by mail and phone. For their participation, families received either an infant t-shirt or a gift card to a national discount department store chain. An additional five mother-infant pairs participated but were excluded due to experimenter error.

Materials

Mothers were asked to demonstrate six object sets to their children. The six objects were chosen to be engaging and novel for infants. We also provided mothers with a list of three actions to perform with each object set, which they could consult during both the familiarization and demonstration phases. See Table 1 for photos of objects and instructions. Three of the objects were chosen to have an enabling-sequence structure; that is, the three suggested actions could be performed

Table 1.

Object		**Instructions**
Lock Box		Your goal is to open the lock box by: – pushing in the buttons 1 and 6 and letting go of the buttons – pressing down on the upper black square button – and lifting the lid (repeat the first step to close the lid)
Xylophone Chute		Your goal is to make the xylophone chute work by: – lifting the blue fabric flap – placing the black tube in the hole so that it fits neatly into the inner cardboard tube – tossing the yellow cone quickly down the black tube to make it come out the bottom hole
Rock Chute		Your goal is to make the rock chute work by: – turning the bottom blue handle on the yellow spiral chute to release the black ball from the bottom holding chamber – placing the ball in the bottom of the lift – turning the blue handle to crank the ball to top, allowing it to drop onto the yellow spiral chute (Note: it appears as if the lift part is supposed to attach to the spiral chute, but it's better if it's placed just a small distance away).

Ball of Whacks		Your goal is to make the ball of whacks work by: – putting the pieces together to form a shape or ball – rolling the ball or shape around the table – squeezing the ball tightly and firmly to make the pieces fall apart
Colored Tubes		Your goal is to make these tubes work by: – expanding and contracting the tubes to make an interesting sound – twisting them into different shapes – snapping them together to form hoops
Sci-Fi Balls		Your goal is to make the sci-fi balls work by: – shaking the object firmly back and forth to make a loud sound – making the colored balls move from side-to-side – and twisting the two sides to allow the balls to move into different tubes

independently in any order, but were required to be completed in a particular order if the mother wanted to achieve the salient goal outcome. The other three objects were chosen to lack this structure; the order of actions for these objects was arbitrary, and the objects lacked an inherent end-goal. This distinction was not highlighted in the instructions. In fact, for all six objects, we described each series of actions as the demonstrator's "goal" in order to make the instructions as similar as possible across conditions.

The objects with enabling-sequence structure were: a white metal "lock box", from which a key could be retrieved by pressing the correct combination of buttons, sliding a latch, and lifting the lid; a specially-created "xylophone chute", into which mothers could insert a large plastic tube, and then slide a wooden object across a set of xylophone keys to make an interesting sound; and a commercially-made plastic "rock chute", with which mothers could crank a handle to transport a plastic "rock" to the top and send it tumbling down a spiral chute. The objects with an arbitrary-sequence structure were: the "ball of whacks", which consisted of 30 magnetized pieces that could be positioned in the shape of a ball as well as other configurations; a set of four plastic "colored tubes" that could be expanded or contracted to make an interesting noise and with ends that could snap together; and a rattle-like toy referred to as the "sci-fi balls", comprised of several clear plastic cylinders with small colored balls which could be moved from cylinder to cylinder by shaking or by twisting and rocking the object.

Procedure

Mothers and infants were greeted in the playroom and informed consent was obtained. The experimenter described the study to the mother as being about "how we demonstrate objects to one another", with no explicit mention of parent-child interaction or the goal structure of the objects. Mothers were then shown into a room with a table containing the six objects. They were given time to read the instructions for each object and to become familiarized with the objects. Infants, meanwhile, were entertained in an adjacent room, so that they could not see the objects. After familiarization, a researcher moved the objects to the experimental room in such a way that the infant could not see them.

Next, mothers and their infants were led into the experimental room. Infants were seated in a high chair at one end of a 5-foot-long table, and mothers were seated at the opposite end, with the set of six objects on a low table beside them but out of the infant's view. A video camera was positioned behind and above the infant's head, such that the mother and a section of the table directly in front of her were recorded from the infant's point of view. Mothers were informed that there would be time after all the demonstrations for their child to play with the objects. They were then asked to demonstrate each object for as long as they liked, one at a time, in the pre-determined order indicated to them. Orders for demonstration were created such that enabling-sequence and arbitrary-sequence objects were blocked but objects within a block were assigned in randomized order. Across participants, half of the mothers demonstrated the enabling-sequence objects first and half of the mothers demonstrated arbitrary-sequence objects first. When mothers were ready, the experimenter began recording, and left the room.

After the mothers were finished demonstrating all objects, the camera was stopped and infants were allowed time to play with the objects. No measures were taken during this time; it was simply a chance for infants to manipulate the attractive objects that had previously been out of reach. The researcher debriefed the mothers and answered any questions.

Coding and Analyses

Videos were coded for the sequence of actions that the mother performed on each object. The list of actions coded for each object included the three primary actions listed on the instructions shown to mothers (always labelled A, B, and C), as well as other actions that emerged as common across participants. For instance, returning the lid to the lock box was necessary before the opening sequence could be repeated, so although it was not in the instructions, it was performed by nearly every mother. This was assigned the letter F. Also, many mothers shook the lock

Table 2. Relevant codes

Enabling-Sequence Objects		
Lockbox	**Xylophone Box**	**Rock Chute**
A. Push buttons B. Slide latch C. Lid off D. Key out E. Key in F. Lid on G. Shake/rattle Z. Other	A. Lift flap B. Tube in opening C. Toss cone in tube D. Remove cone at bottom E. Tube out F. Look through tube Z. Other	A. Dump holding chamber B. Ball onto lift C. Turn lift handle D. Ball drops down chute E. Roll ball on table Z. Other
Arbitrary-Sequence Objects		
Ball of Whacks	**Colored Tubes**	**Sci-fi Balls**
A. Put pieces together B. Take pieces apart C. Roll ball on table D. Squeeze to explode ball Z. Other	A. Twist B. Snap together C. Unsnap D. Contract E. Expand F. Look through G. Put on wrist, head, etc. Z. Other	A. Shake/rattle B. Tilt C. Twist Z. Other

box to make it rattle, or looked through the colored tubes. Thus, these actions were added to the coding scheme and assigned unique letters. Idiosyncratic actions — those performed by only one or two mothers — were coded as "other" and labeled "Z". See Table 2 for a list of relevant codes by object. This allowed us to count every action, to determine the probability of specific sequences of actions, and to find the proportion of two-unit transitions that were in fact repetitions (AA) versus non-repetitions (AB, DB, and so on).

Results

To analyze the patterns of repetitions in enabling-sequence and arbitrary-sequence objects, we first computed transitional probabilities (TPs) for the set of actions performed on each object. Across all subjects, we determined the probability that any given action (e.g., A: pressing the button on the lock box) was followed by any other action (e.g., A: pressing again, or B: sliding the latch). For instance, if the TP from action A to B is .79 on a given object, that indicates that 79% of all A actions were followed immediately by the B action. This is the case for the transition between

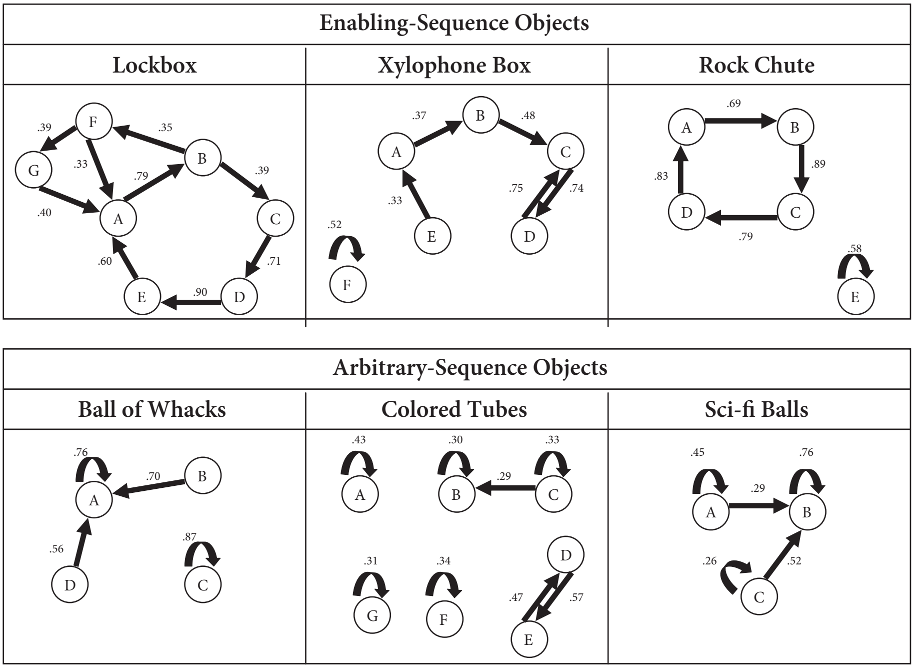


Figure 1. Transitional probability diagrams. Only transitional probabilities higher than .25 are shown.

pressing buttons and sliding the latch of the lock box, as shown in Figure 1. In Figure 1, circles represent the codes unique to each object (refer to Table 2 for the list of codes). Arrows and numbers represent the transitional probabilities; only those above .25 are shown. We used .25 as a very conservative estimate of "chance" based on the object with the fewest typical actions (the sci-fi balls). This object had codes for four actions: A, B, C, and Z (other). Thus, chance occurrence of any code would be .25. Changing estimates of chance based on a higher number of potential actions (and thus a lower TP cut-off) did not substantively change the diagrams.

Visual inspection of Figure 1 shows the striking contrast in TPs between enabling-sequence and arbitrary-sequence objects. As predicted, objects with an enabling-sequence structure are likely to be presented in sequence, with action A being followed by action B, which is followed by action C, etc. On the other hand, objects without the enabling-sequence structure tend to be characterized by repetitions of given units (represented by arrows looping around to point to the same code).

Two additional analyses were undertaken to better quantify these patterns. First, we asked how often mothers completed the full sequence — in order and without interruption — of the three actions provided for them on the instructions

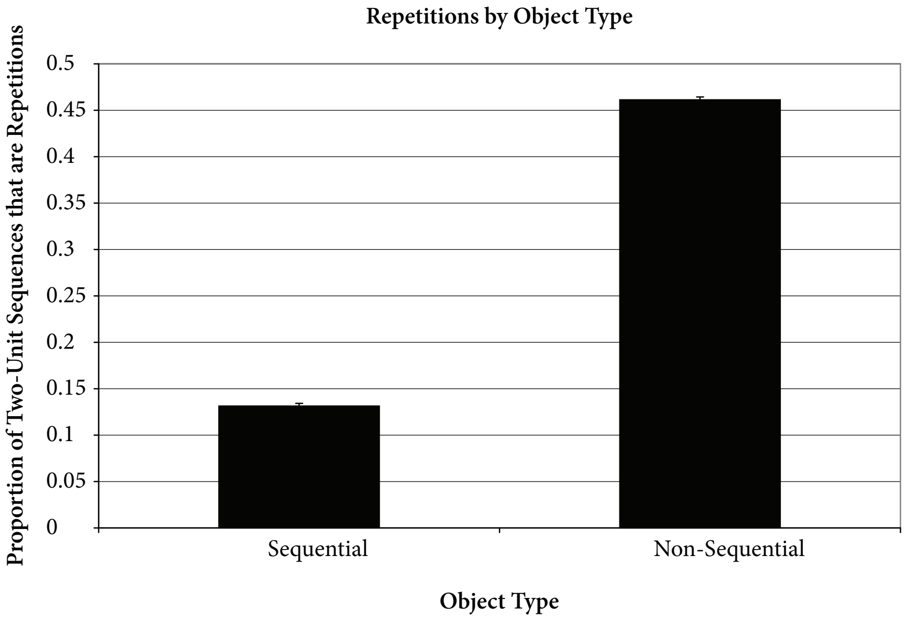


Figure 2. Repetitions (as a proportion of all transitions) by object type.

(ABC). We found, across all subjects, they were more likely to repeat the full sequence for the enabling-sequence objects ($M = 1.59$, $SD = 0.92$, range = 0–7) than the arbitrary-sequence objects ($M = 0.21$, $SD = 0.23$, range = 0–2), paired t $(38) = 9.24$, $p < .0005$. In fact, for enabling-sequence objects, 81% of demonstrations contained the complete sequence at least one time, and 38% contained two or more instances of the whole sequence. For arbitrary-sequence objects, only 18% of demonstrations contained the entire sequence at least once and only 3% contained two or more instances. This pattern of differences remained even if the number of complete sequences was taken *relative* to the total number of actions each mother performed.

Next, we examined whether the use of two-unit repetitions (e.g., AA) versus non-repetitions (e.g., AB) differed depending on type of object, infant age, or sex. We conducted a 2 (object type: enabling versus arbitrary-sequence) x 2 (age group: 6–8 or 11–13 months) x 2 (sex: male or female) ANOVA with the proportion of two-unit series that were repetitions as the dependent variable. Age group and sex were between-subjects factors and object type was a within-subjects factor. As predicted, we found a main effect of object type on this variable. Of all two-unit series, repetitions (AA) comprised a larger proportion in arbitrary-sequence ($M = .46$, $SD = .14$) than enabling-sequence objects ($M = .13$, $SD = .12$), F $(1,35) = 106.91$, $p < .0005$. See Figure 2. There were no other effects for this variable.

Discussion

Across a number of domains, parents and other adults systematically modify their behavior when interacting with babies and when teaching more generally (Csibra & Gergely, 2006, 2009; Fisher & Tokura, 1996; Iverson et al., 1999). One type of modification identified is infant-directed action or "motionese". Motionese appears when adults demonstrate the use of novel objects to infants, and is comprised of a number of features, including repetition and simplification (Brand et al., 2002; Brand et al., 2007). The current paper was an attempt to better understand parents' use of these features when demonstrating objects with and without a salient end-goal which is brought about by a particular ordering of actions.

We provided mothers with objects to demonstrate for their infants that either required a specific series of actions in order to achieve a salient end-goal (enabling-sequence objects) or that had a similar set of unrelated potential actions that did not lead to a salient end-goal (arbitrary-sequence objects). We predicted that when there was no required sequence, mothers would simplify as much as possible by repeating individual units of action only; on the other hand, when there was a sequence to be learned, mothers would string actions together and repeat at the sequence level.

Our findings clearly support this hypothesis. Specifically, in arbitrary-sequence objects, the highest transitional probabilities tended to be for each action to itself (repetitions of units); almost half of all two-unit sequences were repetitions; and mothers rarely cycled through the three suggested actions in order and almost never repeated the entire cycle more than once. Before considering the dimension of goal-structure, this pattern of repetition is what we would have expected in infant-directed action as a way to simplify the action stream and break it down into the smallest possible units. This is analogous to the short sentences, repetition of given words, and increased pauses found in infant-directed speech (Ma et al., 2009).

For the enabling-sequence objects, however, the pattern was markedly different: by far the highest transitional probabilities tended to be from one action to the next in the sequence; only 13% of the two-unit series were repetitions of a given unit; and the most common manner of demonstration was to cycle straight through the listed sequence in order at least once, and often more. At first glance this appears to be exactly opposite of what children might need to learn: instead of providing short simple actions, mothers string together multiple complex series of actions. This almost surely poses additional difficulties for infants' young attention and memory systems. However, in the case of objects with a complicated, sequential-causal structure, mothers' actions in fact highlight the transitions from one action to the next. These transitions are crucial to learn for activating the most salient aspect of the object, but arguably even harder for infants to learn than individual actions. Thus, when the sequence is crucial, mothers rarely interrupt the sequence by repeating individual units; instead, they cycle through all the actions before repeating the series.

We suspect that at least some features of motionese are distinctly pedagogical in nature; that is, when parents and other experts teach infants, they naturally provide cues that engage their attention and perhaps signal a specific kind of learning scenario (Csibra & Gergely, 2006). For instance, the enhanced eye-contact and calling of infants' names, which is ubiquitous in these kinds of interactions, are hypothesized to function in this way. Further, we suspect mothers' choice to repeat action units or entire sequences of action might also serve a specific teaching function, helping infants to learn about the distinct ways that the intentional manipulation of objects can achieve various goal states. However, we recognize that it is impossible to conclude a pedagogical function of repetition from the current data. One might argue, for instance, that the enabling-sequence objects constrained mothers so that they were simply not able to repeat at the unit level because the object must immediately proceed from one step to another. In fact, this is not the case. With the lock box, for instance, mothers *could have* repeatedly pressed on the buttons and lifted their fingers away as a way to highlight this step and to ensure infants caught on before sliding the latch. However, they simply chose not to do that. Yet, with no differences between age groups and no "expert-learner" comparison group, it is still possible that the differences between enabling-sequence and arbitrary-sequence objects stemmed from the affordances of the objects themsevles moreso than from a deliberate effort to teach sequences versus units. This will have to be addressed in additional research.

There are a number of ways future research could shore up the argument that motionese functions pedagogically. One would be to examine the pattern of mothers' behavior in the context of infants' concurrent behavior. In other words, do mothers' modify their motionese *on-line* in response to the behaviors of their infants? One might expect, for instance, that at least some repetitions of action are intended to make up for a noted lapse in infant attention. A second route would be to provide evidence of differential learning from different types of demonstration, to show that motionese-demonstrated actions are more easily learned than adult-directed actions, and that enabling sequences are more easily learned by repetitions of sequences rather than units. In other work, people have shown sensitivity to the linking of chunks of information through repeated exposure (Avrahami & Kareev, 1994; Brand & Tapscott, 2007; Saffran et al., 2004); thus, infants are likely to glean different information from a demonstration depending on whether units or sequences are repeated in demonstrations. Research is underway exploring each of these issues.

Despite the limitations described above, we feel that the findings make an important contribution to the motionese literature and to the broader question of action recognition. Whether the patterns related to goal structure are specifically pedagogical or not, they are nevertheless richly informative to infants in their attempts to learn about complex human artifacts and our interactions with them. In addition, the current work illuminates the issue of how to define and measure the feature of repetition in action demonstrations. It is not enough to consider the number of times a given action unit is repeated; instead, researchers must take into consideration which portions of action are being repeated, and in which combinations.

In summary, when demonstrating objects to infants with distinctly different goal structures, mothers spontaneously modified their use of repetition. When objects were such that individual action units were unrelated to one another and there was no salient end-goal, mothers simplified by repeating individual units rather than stringing units together. When objects were such that the series of three actions needed to be enacted in sequence to achieve a salient goal, mothers eschewed repetition of individual units and instead repeatedly cycled through the series, presumably to demonstrate the importance of the transitions in activating the object. This may or may not have been deliberately pedagogical on mothers' part, but nevertheless indicates another way in which input to infants is richly patterned to support their learning.

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