frontiers | Frontiers in Communication

TYPE Brief Research Report
PUBLISHED 20 October 2022
DOI 10.3389/fcomm.2022.922405

OPEN ACCESS

EDITED BY
Vito Evola,
Universidade NOVA de Lisboa,
Portugal

REVIEWED BY
Elisabeth Zima,
University of Freiburg, Germany
Asli Aktan-Erciyes,
Kadir Has University, Turkey

*CORRESPONDENCE
Katharina J. Rohlfing
katharina.rohlfing@uni-paderborn.de

SPECIALTY SECTION
This article was submitted to Multimodality of Communication, a section of the journal Frontiers in Communication

RECEIVED 17 April 2022
ACCEPTED 12 September 2022
PUBLISHED 20 October 2022

CITATION
Rohlfing KJ, Vollmer A-L, Fritsch J and Wrede B (2022) Which "motionese" parameters change with children's age? Disentangling attention-getting from action-structuring modifications. *Front. Commun.* 7:922405.
doi: 10.3389/fcomm.2022.922405

Which "motionese" parameters change with children's age? Disentangling attention-getting from action-structuring modifications

Katharina J. Rohlfing[1]*, Anna-Lisa Vollmer[2], Jannik Fritsch[3] and Britta Wrede[4]

[1]Faculty of Arts and Humanities, Paderborn University, Paderborn, Germany, [2]Medical School OWL, Bielefeld University, Bielefeld, Germany, [3]Faculty of Technology, Bielefeld University, Bielefeld, Germany, [4]Faculty of Computer Science, University of Bremen, Bremen, Germany

Modified action demonstration—dubbed *motionese*—has been proposed as a way to help children recognize the structure and meaning of actions. However, until now, it has been investigated only in young infants. This brief research report presents findings from a cross-sectional study of parental action demonstrations to three groups of 8–11, 12–23, and 24–30-month-old children that applied seven motionese parameters; a second study investigated the youngest group of participants longitudinally to corroborate the cross-sectional results. Results of both studies suggested that four motionese parameters (Motion Pauses, Pace, Velocity, Acceleration) seem to structure the action by organizing it in motion pauses. Whereas these parameters persist over different ages, three other parameters (Demonstration Length, Roundness, and Range) occur predominantly in the younger group and seem to serve to organize infants' attention on the basis of movement. Results are discussed in terms of facilitative vs. pedagogical learning.

KEYWORDS

parental adaptation, motionese, social learning, action demonstration, tutoring

Introduction

When addressing children, caregivers modify their behavior in terms of speech (Fernald and Mazzie, 1991; Dominey and Dodane, 2004; Fischer, 2016), gesture (Iverson et al., 1999; Grimminger et al., 2010), and motion (Gogate et al., 2000; Brand et al., 2002). The value of these partner adaptations has been recognized across disciplines (Schober and Brennan, 2003), and they have been discussed as promoting children's recognition of structure and meaning in the input (Zukow-Goldring, 2006; Brand and Tapscott, 2007). Educational studies recommend that caregivers should apply these behavioral modifications to help them attune to children's capabilities and establish a solid basis for learning (Wood et al., 1976; Snow, 1977; Legerstee, 2005). Moreover, studies on the development of artificial systems also use these modifications as strategies for reducing the complexity of input and boosting learning processes by highlighting relevant information (Rohlfing et al., 2006; Nagai and Rohlfing, 2009).

Although these modifications are well-described in speech, their parameters in action are less concrete. Action demonstration—dubbed "motionese" (Brand et al., 2002, p. 72)—is vaguely characterized as "the use of exaggerated and repetitive hand gestures toward infants" (Hirai et al., 2022, p. 1). Being more exact about the parameters, Brand et al. (2002) found that in comparison to adult-directed actions, parents amplify some characteristics such as rate, enthusiasm, or simplifications. Using objective measures, Rohlfing et al. (2006) found that when addressing children, parents' actions were less round (i.e., straight movements) and slower paced (i.e., shorter movement phases with more pauses between each successive single movement) compared to adult-directed actions. However, it is not clear how these parameters might change with children's age and thus developing competencies.

Corroborating the view that the adaptability of communicative behavior is not a uniform process (Brown and Dell, 1987), some approaches view the function of modifications in the ostension as being to attract children's attention (Csibra and Gergely, 2011). Other approaches discuss the structuring function as conveying a better understanding of which parts of a demonstration are relevant (Wood et al., 1976). The structuring function is important because many cultures do not practice explicit teaching. Instead, when an action is structured by "task decomposition" (Sterelny, 2012, p. 35), facilitative teaching takes place, giving children opportunities for learning without being addressed directly (Nakao and Andrews, 2014).

With increasing age, children are more able to perceive a task structure: Lohan et al. (2014) found significant differences between children's age groups (8–11 vs. 25–30 months old) in the likelihood of anticipating the target position of objects. This anticipation, becoming perceivable through children's gaze, can be informative for parents monitoring their children. Pitsch et al. (2014) found that at the age of 8–11 months, 39% of the infants they studied anticipated the goal position of a target object; and during action pauses, 11% anticipated a relevant object for the next action. Crucially, this anticipatory gaze behavior was linked to parental action demonstrations: The infants' anticipation at "checkpoints" (e.g., pauses by the presenter) was "likely to be treated as a display of action understanding," whereas anticipation outside such points, e.g., during subactions, was interpreted as "lack of attention" (Pitsch et al., 2014, p. 88) resulting in a modification of the action range. Checkpoints thus refer to parts of the demonstrated actions that the presenter seems to intend as interim positions—confirming the assumption by Wood et al. (1976) in another context that tutors need to develop a knowledge of the task and its subparts to teach it successfully. At checkpoints, tutor's knowledge about the task is exchanged more closely with the partner, and an agreement is established by partners monitoring each other. Thus, it is not only the parents' intention to teach their children an action that is driving their modifications in action performance, but rather the close loop between their demonstration and the child's perception and understanding of the task structure (Pitsch et al., 2014).

This report presents two studies aiming to explore whether we can disentangle the ostensive from the task-structuring function by looking at which action parameters change with children's age. We reasoned that some motionese parameters will persist across ages because they are responsible for structuring the task. Following Pitsch et al. (2014), we hypothesized that some parameters such as Roundness and Range would address perceptual skills only in young children.

Study 1

Method

Participants

Parents of 47 children participated in this cross-sectional study. All were identified as Caucasian or European, German-fluent, and the biological parents of first- (53.7%) or second-born children. They had completed formal education with a secondary school diploma (15%) or university-entrance diploma (85%). The different age groups of children (see Supplementary Table A) matched milestones in language development: nonverbal (8–11 months), early-lexical (12–23 months), and advanced lexical (24–30 months).

Parents were recruited in Bielefeld (Germany) and surroundings by newspaper ads and flyers. The original sample contained 90 parents (47 mothers of whom 4 were single parents and 43 fathers) resulting in 90 child-directed (CDA) and 90 adult-directed action (ADA) demonstrations. This dropped to 168 (84 CDA, 84 ADA performed by 43 mothers and 41 fathers), because in 12 either technical or procedural errors occurred.

Stimuli

The following 10 items were objects of demonstrations: a lamp at the beginning; a bell, blocks, cups, stamps, and a sliding door in a second group; and a box with books, box with rings, a bag with a zipper, and a salt shaker in a third group. Items were randomized within the three groups. For the present analysis of action parameters, we chose those items that met both of the following two conditions (see Figure 1): (a) They presented comparable movements in the action demonstrations across tutors; (b) they had a seriating action structure with each action consisting of three separate subactions.

Procedure

Both parents and their child were invited to the DialogLab at Bielefeld University. First, informed consent was obtained from each child's parent. Then, the parent who spent more everyday time with the child was invited to another room and asked to

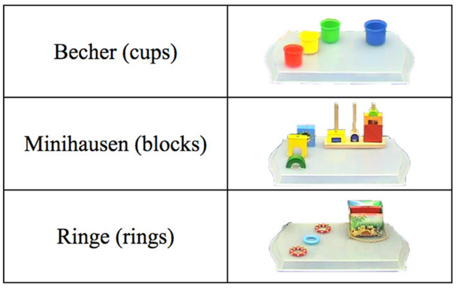


FIGURE 1
The experimental items included in our analysis. *Becher* used different-sized cups with the largest placed to the left of a tray and the other cups on the right-hand side. This tray was placed in front of the presenter who was then asked to stack the cups into each other, beginning with the cup closest to them (green). For *Minihausen*, a wooden construction including three poles was presented in the middle of a tray with three blocks on the side. The presenter was instructed to start with the individual blocks and to put them on the poles one after the other. Finally, for *Ringe*, a box was presented in the middle of the tray that was placed in front of the presenter who was then instructed to put the individual rings into the box, one after the other. These three items were chosen, because each task could be performed by three subactions (see Codings) of taking an object and changing its location.

demonstrate actions with the 10 items to the child sitting across a table. The experimental items were presented successively on a tray on the parent's side of the table so that the child was unable to reach them. The procedure always started with a warm-up item. Two cameras were used: one recording the parent and the other recording the infant, both from the front. Parents were given open instructions before each item: e.g., "Bitte zeigen Sie wie man die Becher ineinander stapelt! Bitte fangen Sie mit dem Körpernächsten an [Please demonstrate how to stack the cups into each other! Please begin with the one closest to you]!" After the instruction, the experimenter hid behind a curtain to one side of the table so as to be out of the child's sight, and the parent demonstrated the actions. The task was completed when all three objects were transported to the goal object (goal position). Next, the parent was asked to demonstrate the actions to the other parent (or to an experimenter in the case of single parents). As a further step, the second parent was asked to demonstrate the actions to the child. Finally, the second parent interacted with another adult (a second experimenter). This addressee was asked to just look at the demonstration, no further action execution was requested, and the objects were out of the addressee's reach. In sum, each participating child was presented with two demonstrations: one from each parent.

Coding

To analyze modifications in the actions performed, data from interactions among adults were collected with the same stimuli. The video data were annotated both manually and semiautomatically. First, the structure of the parental demonstration and the hand with which each subaction was carried out (either right or left) were annotated manually using the timeline-based annotation software ELAN (Brugman and Russel, 2004). A ***subaction*** a_i, *with* $i \in \{1, 2, 3\}$ was defined as beginning exactly in that frame in which the parent had a tight grasp on the i-th object before starting to lift it upward in the next frame. The subaction ended at the time of the exact frame when the parent next released the object to its goal position, meaning the frame in which the parent was still holding the object before releasing it in the next frame.

Second, the motion trajectories of the parent's hands were captured with a semiautomatic 2D motion tracker (Vollmer et al., 2009). This tool records the x and y coordinates for the position of the parent's hands for each frame in the video image. It uses optical flow to estimate the positions of the hands in the next frame, and visualizes them via red and pink dots in the image. The recorded positions were stored in a text file loaded into MATLAB for further analyses. We segmented the trajectory into movements and pauses based on motion speed. If the velocity of the acting hand was below a threshold of 25 pixels/s for longer than three consecutive frames, this part of the trajectory was denoted a ***Pause***. All other parts were declared ***Movements***.

To analyze the motion from the trajectory segments, we extended previous studies (Brand et al., 2002; Rohlfing et al., 2006; Vollmer et al., 2009) by defining seven objective motion parameters (Table 1). The new parameter Range controls for the distance of the objects and assigns a higher value to an action that was longer than the distance between the objects. When, e.g., two cups were apart from each other, the action path was long; the action's path could also be long when two cups were close to each other, and the action shifted about between them.

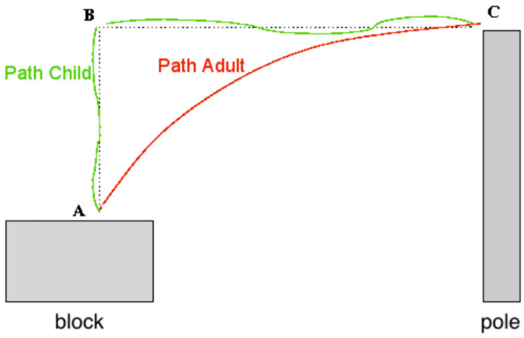
Measures were computed for each of the three experimental items and then averaged across items separately for each participant.

Results

Pursuing the question of whether the action parameters (Table 1) of the three analyzed tasks differed when performed toward adults and children of different ages, we applied a 2 (addressee: child or adult as a within-group factor) × 3 (age group as a between-group factor) mixed-design analysis of variance to all parameters. For these analyses, uncorrected alpha was set at 0.05.

With regard to Demonstration Length, there was a main effect of age, $F_{(2,76)} = 7.65$, $p < 0.001$, $\eta_p^2 = 0.17$, showing that the task took longer in Age Group 1 compared to Age Groups 2 ($p < 0.05$) and 3 ($p < 0.01$). Table 2 depicts those Scheffé *post hoc* tests that attained significance. Groups 2 and 3 did not differ significantly ($p = 0.75$). We also found a large main effect of addressee, $F_{(1,76)} = 64.19$, $p < 0.001$, $\eta_p^2 = 0.46$,

TABLE 1 The dependent measures—i.e., the parameters of action modification.



Example of an action: Putting a block on a pole (Minihausen)

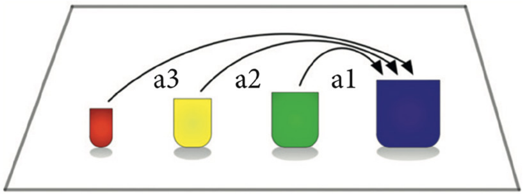
Parameter	Measurement unit	Definition
Demonstration length	s	 Time in s from the beginning of the first subaction (a1) of a demonstration to the end of the last subaction (a3). This measure does not use any information about pauses or movements during the demonstration: The higher the value, the longer the demonstration. In the example with the block and the pole (see first row), the child-directed action of putting a block on a pole follows a path consisting of AB and BC, which is longer than AC (an adult-directed action).
Roundness	Pixels/pixels	The roundness of an action is calculated as the average roundness of all its movements. The roundness of a movement is calculated by dividing the traveled path [pixels] between movement on- and offset by the distance [pixels] (measured in a straight line) between movement on- and off-set. This measure results in a low value when the movement is particularly square with pauses at the vertices; in contrast, it results in high values when the movement is round. In the example in which a block is put on a pole, the action follows a round path (red line) that is rounder than the child-directed path (green line).
Range	Pixels/pixels	In contrast to Roundness, Range is calculated for each subaction demonstration and does not use the division into movements and pauses. It reflects a relation between the length of a path [pixels] divided by the distance [pixels] between the subaction's on- and offset. When the average of the quotients obtained has a high value, the action is being performed with a longer path traveled in relation to the distance of path on- and offset.
Pace	Frames/frames	The average of all quotients obtained by dividing the duration of each movement [frames] by the duration of its preceding pause [frames]. This denotes the quotient of movement duration and pause duration for an action. High values indicate that the action is performed with long movement phases and relatively short pauses.
Motion pauses	% of action in s	The total length of all motion pauses in an action by calculating the percentage of pauses of an action. More and (or) longer pauses are performed when the number is high. In the example above, it can be seen that the pause (B) is performed during the execution of child-directed movement.
Velocity	Pixels/s	Computed in [pixels/s] only for all movement parts of an action. Movement of the action is faster when the number is high.
Acceleration	Pixels/s^2	Calculated in [pixels/s^2] for all movement parts of an action. The movement accelerates more when the number is high.

TABLE 2 Results from Study 1 along the parameters for action modifications conveying means, *SDs*, and significant effects (*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$).

	Age group						Effects found in	
	1 (8–11 months, $M = 10.2$ $SD = 1.2$) 7 girls, 9 boys		2 (12–23 months, $M = 18.9$ $SD = 3.1$) 7 girls, 9 boys		3 (24–30 months, $M = 27.1$ $SD = 2.1$) 10 girls, 5 boys		Age	Addressee
	CDA	ADA	CDA	ADA	CDA	ADA		
Demonstration length (s)	13.29	6.63	9.47	5.1	8.45	4.61	1 > 2*	In all groups:
	(7.06)	(3.1)	(4.79)	(2.16)	(3.57)	(2.01)	1 > 3*	CDA > ADA**
Roundness (pixels/pixels)	4.59	8.18	6.16	6.92	12.26	9.21	Interaction: age × addressee	
	(3.56)	(5.55)	(3.96)	(3.89)	(10.84)	(3.37)	Group 1: CDA < ADA***	
Range (pixels/pixels)	2.98	2.19	2.61	1.98	1.75	1.64	1 > 3*	In all groups:
	(1.46)	(0.81)	(2.21)	(0.6)	(0.84)	(0.53)		CDA > ADA**
Pace (frames/frames)	11.08	40.11	21.13	33.11	21.11	49.51		In all groups:
	(14.18)	(24.86)	(27.5)	(21.51)	(38.29)	(27.4)		CDA < ADA***
Motion pauses (% of action in s)	20.17	6.82	18.13	7.11	15.89	4.12		In all groups:
	(11.31)	(5.87)	(12.44)	(7.85)	(8.37)	(5.04)		CDA > ADA***
Velocity (pixels/s)	148.85	231.33	169.98	229.68	162.96	247.75		In all groups:
	(34.33)	(51.61)	(41.86)	(66.62)	(57.08)	(65.41)		CDA < ADA***
Acceleration (pixels/s^2)	42.07	59.78	41.93	60.25	37.7	65.21		In all groups:
	(12.20)	(17.8)	(11.29)	(22.56)	(16.52)	(21.03)		CDA < ADA***

indicating that demonstrations were significantly longer when performed toward a child (CDA) rather than an adult (ADA) across age groups.

In terms of Roundness, the data revealed an intermediate interaction effect, $F_{(2,75)} = 5.84, p < 0.01, \eta_p^2 = 0.14$, and Scheffé *post hoc* tests indicated a significant difference between CDA and ADA only in Group 1, $t(30) = -3.35$, $p < 0.01$, meaning that actions were performed less roundly for young children.

For the parameter Range, we found intermediate main effects of age, $F_{(2,75)} = 4.79, p < 0.05, \eta_p^2 = 0.11$, and addressee, $F_{(1,75)} = 8.53$, $p < 0.05$, $\eta_p^2 = 0.10$, indicating that CDAs were performed with a significantly greater range (i.e., more distance between movement on- and offset) than ADAs across age groups, and that actions were performed with significantly greater range in Group 1 than in Group 3 ($p < 0.05$ according to a Scheffé *post hoc* test). Groups 1 and 2 ($p = 0.55$) and Groups 2 and 3 ($p = 0.14$) did not differ significantly.

Looking at the parameter Pace, CDA and ADA differed significantly in all age groups as suggested by the large main effect of addressee, $F_{(1,76)} = 37.46$, $p < 0.001$, $\eta_p^2 = 0.33$. Accordingly, CDA was performed with less pace than ADA. In other words, in CDA, comparatively short movements were paired with relatively long pauses.

We also found a large main effect of addressee for the parameter Motion Pauses, $F_{(1,76)} = 88.23, p < 0.001, \eta_p^2 = 0.54$. In all age groups, parents produced significantly more pauses toward their children than toward other adults.

We also found a strong main effect of addressee for Velocity, $F_{(1,76)} = 146.07, p < 0.001, \eta_p^2 = 0.66$, and Acceleration, $F_{(1,75)} = 96.54$, $p < 0.001$, $\eta_p^2 = 0.56$, revealing that in all age groups, CDA were significantly slower and less accelerated than ADA.

In summary, we obtained results suggesting that the action parameters Pace, Motion Pauses, Velocity, and Acceleration were equally present in all age groups, whereas the parameters Roundness, Range, and Demonstration Length seem to be modified primarily toward younger children.

Study 2

In the following second study, the youngest group was investigated longitudinally to corroborate the findings obtained cross-sectionally.

Method

This longitudinal study focused on nine mothers and nine fathers. This sample size was a product of the necessary data reduction due to technical issues in recording and processing (data of one child excluded). All participants were German-fluent and the biological parents of first- (to 50%) or second-born children (see Supplementary Table B). They had completed formal education with either a secondary school diploma (6.2%)

TABLE 3 Results from Study 2 along the parameters for action modifications conveying means, *SDs*, and significant effects ($^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$).

	Data point (age of children)				Effects found in	
	1st 8–11 months ($M = 10$, $SD = 1.1$), 3 girls and 6 boys		2nd 12–23 months ($M = 17.5$, $SD = 2.4$), 3 girls and 6 boys		Age	Addressee
	CDA	ADA	CDA	ADA		
Demonstration length (s)	11.02 (6.00)	6.56 (3.23)	8.51 (4.03)	4.58 (1.41)	1 > 2*	CDA > ADA***
Roundness (pixels/pixels)	4.94 (3.84)	9.4 (7.2)	6.97 (5.3)	6.16 (2.11)	Interaction: age × addressee	
					Time 1: CDA < ADA*	
Range (pixels/pixels)	2.5 (1.01)	2.28 (0.98)	2.28 (0.98)	2.11 (0.47)		CDA > ADA*
Pace (frames/frames)	8.6 (9.01)	42.56 (22.87)	16.2 (19.56)	37.36 (19.6)	Interaction: age x addressee	
					Time 1: CDA < ADA***	
					Time 2: CDA < ADA**	
					CDA: Time 1 < Time 2*	
Motion pauses (% of action in s)	18.7 (10.9)	5.43 (4.66)	15.14 (8.32)	5.57 (5.43)		CDA > ADA***
Velocity (pixels/s)	0.15 (0.035)	0.24 (0.05)	0.16 (0.03)	0.21 (0.04)	Interaction: age × addressee	
					Time 1: CDA < ADA***	
					Time 2: CDA < ADA***	
					ADA: Time 1 > Time 2*	
Acceleration (pixels/s^2)	0.04 (0.01)	0.06 (0.02)	0.04 (0.01)	0.06 (0.02)		CDA < ADA**

or a university-entrance diploma (93.7%). All participants were identified as Caucasian or European.

The stimuli and procedure were the same as in Study 1, with the second assessment being carried out after about 8 months.

Results

To investigate longitudinal effects in parental action modifications toward children, we applied a 2 (children's age: Time 1 and Time 2) × 2 (addressee: child vs. adult) repeated measure analysis of variance to all parameters (Table 3).

With regard to Demonstration Length, we found a significant main effect of age, $F_{(1,17)} = 6.83$, $p < 0.05$, $\eta_p^2 = 0.29$, and a large main effect of addressee, $F(1, 17) = 21.59$, $p < 0.001$, $\eta_p^2 = 0.56$. Both effects indicate that demonstrations were longer when performed at Time 1 than Time 2, but that demonstrations toward children were longer than toward adults across both times.

In terms of Roundness,[1] we found a significant interaction effect, $F_{(1,16)} = 4.82$, $p < 0.05$, $\eta_p^2 = 0.23$. Bonferroni-corrected *post hoc* analyses with a significance level of 0.025 indicated a significant difference between CDA and ADA only for Time 1, $F_{(1,16)} = 4.83$, $p < 0.05$, $\eta_p^2 = 0.23$. This result is in line with findings from Study 1. Accordingly, ADA for younger children was performed with rounder movements than CDA.

For the parameter Range, we found a main effect of addressee, $F_{(1,17)} = 7.94$, $p < 0.05$, $\eta_p^2 = 0.32$, according to which CDA was performed with a greater range, i.e., more distance between the on- and offsets of actions.

We found a significant interaction effect for the parameter Pace, $F_{(1,17)} = 4.88$, $p < .05$, $\eta_p^2 = .22$, and a significant main effect for addressee, $F_{(1,17)} = 37.14$, $p < .001$, $\eta_p^2 = 0.69$, indicating that at both time points, CDA was performed with greater pace than ADA: Time 1, $F_{(1,17)} = 35.48$, $p < 0.001$, $\eta_p^2 = 0.68$; Time 2, $F_{(1,17)} = 8.72$, $p < 0.01$, $\eta_p^2 = 0.34$, with Bonferroni correction). However, between time points, Pace seemed to increase for CDA but not for ADA: $F_{(1,17)} = 4.59$, $p < 0.05$, $\eta_p^2 = 0.21$, Bonferroni-corrected for CDA.

For the parameter Motion Pauses, there was a large main effect of addressee, $F_{(1,17)} = 30.09$, $p < 0.001$, $\eta_p^2 = 0.64$. Accordingly, ADA was performed with fewer pauses than CDA.

We also found an interaction effect and a main effect of addressee for the parameter Velocity, $F_{(1,11)} = 31.33$, $p < 0.01$, $\eta_p^2 = 0.74$, according to which CDAs were slower than ADAs across both time points: Time 1, $F_{(1,17)} = 51.7$, $p < 0.001$, $\eta_p^2 = 0.75$; Time 2, $F_{(1,17)} = 31.28$, $p < 0.001$ $\eta_p^2 = 0.65$, with

1 For this parameter, we identified one univariate outlier (with a standardized *z* score of 3.99) with a value greater than the mean plus two times the standard deviation that we deleted from the data set (Tabachnick and Fidell, 2001).

Bonferroni correction. Additionally, ADAs were slower at Time 2 than Time 1, $F_{(1,17)} = 6.88$, $p < 0.05$, $\eta_p^2 = 0.29$.

For Acceleration, we found a main effect of addressee, $F_{(1,17)} = 34.58$, $p < 0.001$, $\eta_p^2 = 0.67$, indicating that parents accelerated their movements less when demonstrating actions to children than when demonstrating to adults.

In summary, our results suggest that the action parameters Range, Pace, Motion Pauses, Velocity, and Acceleration were equally present across both time points, whereas the parameters Roundness and Demonstration Length were salient toward younger children.

Discussion

Our research analyzed parental demonstrations of actions to children of different ages and compared these to action demonstrations addressing another adult. Our first study took a cross-sectional approach. Extending available measurements, we applied seven action parameters that assess motionese, and we explored whether and to what degree action modifications persist across three groups of children aged 8–11, 12–23, and 24–30 months. We found main effects of addressee for the parameters Pace, Motion Pauses, Velocity, and Acceleration suggesting that for all age groups, actions were performed differently in an interaction with a child than with an adult: Adult-directed actions (ADA) were performed with accelerated, long movements and at a higher velocity, and these were followed immediately by both shorter and fewer pauses. This finding is in line with previous work suggesting that these parameters persist as an action modification across development, regardless of how the interaction partner will react to them. A study by Herberg (2008) showed that adult participants performed a different kind of action toward a picture of a computer than a picture of another adult. This suggests that some modifications will appear without any need for interactive feedback from an interaction partner.

In contrast to Herberg's (2008) study, which was based on only one time point, our longitudinal study found that ADA performance decreased in Velocity from Time 1 to Time 2. Making similar observations for the other parameters in the result plots, we interpret this effect as a familiarization with the study design, with parents at Time 2 mimicking how they demonstrated the actions to their children because, at Time 2, the tasks were all known. This effect can also be interpreted as reflecting a stronger orientation toward the recipient (Clark and Krych, 2004), i.e., movements are adjusted to what the partner already knows about the task (Brown and Dell, 1987).

As to why these parameters persist over different ages, we argue that they seem to structure the action by organizing it through motion pauses. Those pauses, negatively correlating with Roundness in CDA, might constitute "checkpoints" at which it is possible for interaction partners to display common understanding in the construction of the task. In other words, such checkpoints provide an opportunity for children to anticipate further action and to display understanding of or just readiness for the action demonstration. Pitsch et al. (2014) have remarked that caregivers interpret infants' anticipation outside such points as a lack of interest and attention to the task. However, it is important to note that the idea of checkpoints is still under development, and we cannot state whether every pause during an action demonstration is relevant. We speculate that only pauses related to the presenter's knowledge about the task (Wood et al., 1976) will qualify as checkpoints. Certainly, there is a need to determine more objective measures for them.

When we analyzed the parameters Demonstration Length, Roundness, and Range, we were able to replicate the effect of age group longitudinally, thereby revealing that these parameters were modified in parental behavior: in other words, longer demonstrations consisting of less round movements when performed toward infants at the age of 10 months compared to 17.5 months. The analysis of Range further indicated that this parameter remains a part of parental modifications till the age of 17.5 months but fades away by the age of 24 months.

The function of these parameters when addressing young children might be to increase the salience of the actions: Overall longer performance that has a wider range and is less round suggests the aim of engaging children's attention, because the individual movements appear dynamic and exaggerated, and therefore more salient than a round and more direct motion. In line with this dynamics, Matatyaho and Gogate (2008) showed that parents perform actions such as shaking or looming to highlight some aspects in natural interactions. In addition, if they lose children's interest, caregivers modify their action range in an effort to regain infants' attention to the task (Pitsch et al., 2014). It thus seems that these parameters may be adjusted particularly to younger children's perception of action. Young infants at the age of 6–11 months have been shown to prefer such modified actions (Brand and Shallcross, 2008). Thus, modifications might result from or characterize repairs within an interaction that are needed more often in interaction with young children. One further possible explanation is that motion parameters observable in interactions with young children become replaced with other means such as language. It is reasonable to assume that parents of children who understand aspects of action manner and goal might guide their children more by means of language and less by means of action. A study by Gerson and Woodward (2014) used labeling to support infants' sensitivity to the goal structure of others' actions. Their results strongly suggested that language facilitated infants' understanding of a novel action as being goal-directed. In the course of development, language thus seems to become a more powerful means of expanding knowledge about actions.

Together, our results suggest that motionese parameters related to the tempo of the demonstrations such as Pace, Motion Pauses, Velocity, and Acceleration persist in child-directed actions (CDA) over different ages and appear to structure the action by organizing it with motion pauses. Other parameters such as Demonstration Length, Roundness, and Range result in longer demonstrations with less round and longer movements (higher Range) within the subactions and are pronounced when addressing young children and probably serve attention organization.

One limitation to our investigation is that we did not focus on the interaction loop. Fukuyama et al. (2014) have shown that parents change their way of demonstrating depending on their 11- to 13-month-old infants' ability to reproduce the movements. In line with this interactional loop, Koterba and Iverson (2009) already demonstrated that 8- to 10-month-old infants' manipulation and exploration of objects change depending on how the action is demonstrated. Another crucial limitation is the setting involving a task that was (too) easy for the adults. Even though participants were asked to demonstrate actions with the simple toys, they might have just performed the motions without trying to convey any information. Because the addressee's knowledge has been found to crucially influence the speaker's way of communication, even among adults (Brown and Dell, 1987), it is possible that the difference between CDA and ADA revealed in our data actually reflects teaching vs. nonteaching behavior. Nonetheless, even with this limitation, our results focus on audience-designed differences in nonverbal behavior performed by parents across different ages, and show that the intensity of the difference can change depending on the child's age as was the case for Demonstration Length and Roundness.

Beside these limitations, our research provides further important impulses for future studies on motionese: Because infants' preference for motionese has been documented (Brand and Shallcross, 2008) without specifying which parameters infants are attracted to, we now need to disentangle whether the preference for motionese is based on the attention-getting parameters of motion (Demonstration Length, Roundness, and Range), the action-structuring parameters, or all parameters together. Studys on different populations could clarify whether children vary in the way they perceive the two motionese parameter groups (attention getting vs. action structuring).

Data availability statement

The original data presented in the study are summarized in the article (Tables 2, 3), further inquiries can be directed to the corresponding author. The data are not publicly available because the informed consent form did not include this possibility.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

KR, JF, and BW: conceptualization and supervision. KR and BW: methodology. KR and JF: data acquisition. A-LV, JF, and KR: data analysis. KR and A-LV: original draft preparation. KR, A-LV, and BW: funding acquisition. All authors have read and agreed to the published version of the manuscript.

Funding

This study was made possible by funding from Bielefeld University to KR. The preparation of the manuscript was funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation): TRR 318/1 2021-438445824 and partly by the Collaborative Research Center SFB 1320 'EASE - Everyday Activity Science and Engineering'.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcomm.2022.922405/full#supplementary-material

References

Brand, R. J., Baldwin, D. A., and Ashburn, L. A. (2002). Evidence for "motionese": modifications in mothers' infant-directed action. *Develop. Sci.* 5, 72–83. doi: 10.1111/1467-7687.00211

Brand, R. J., and Shallcross, W. (2008). Infants prefer motionese to adult-directed action. *Develop. Sci.* 11, 853–861. doi: 10.1111/j.1467-7687.2008.00734.x

Brand, R. J., and Tapscott, S. (2007). Acoustic packaging of action sequences by infants. *Infancy* 11, 321–332. doi: 10.1111/j.1532-7078.2007.tb00230.x

Brown, P. M., and Dell, G. S. (1987). Adapting production to comprehension: the explicit mention of instruments. *Cognit. Psychol.* 19, 441–472.

Brugman, H., and Russel, A. (2004). "Annotating multimedia/multi-modal resources with ELAN," in *Proceedings of LREC 2004, Fourth International Conference on Language Resources and Evaluation* (Nijmegen: Max Planck Institute for Psycholinguistics, The Language Archive). Available online at: http://tla.mpi.nl/tools/tla-tools/elan/ (accessed September 25, 2022).

Clark, H. H., and Krych, M. A. (2004). Speaking while monitoring addressees for understanding. *J. Memory Lang.* 50, 62–81. doi: 10.1016/j.jml.2003.08.004

Csibra, G., and Gergely, G. (2011). Natural pedagogy as evolutionary adaptation. *Philos. Trans. R. Soc. B Biol. Sci.* 366, 1149–1157. doi: 10.1098/rstb.2010.0319

Dominey, P. F., and Dodane, C. (2004). Indeterminacy in language acquisition: the role of child directed speech and joint attention. *J. Neuroling.* 17, 121–145. doi: 10.1016/S0911-6044(03)00056-3

Fernald, A., and Mazzie, C. (1991). Prosody and focus in speech to infants and adults. *Develop. Psychol.* 27, 209–221.

Fischer, K. (2016). *Designing Speech for a Recipient: The Roles of Partner Modeling, Alignment and Feedback in So-Called 'Simplified Registers'*. Amsterdam: John Benjamins Publishing Company. doi: 10.1075/pbns.270

Fukuyama, H., Qin, S., Kanakogi, Y., Nagai, Y., Asada, M., and Myowa-Yamakoshi, M. (2014). Infant's action skill dynamically modulates parental action demonstration in the dyadic interaction. *Develop. Sci.* 18, 1006–1013. doi: 10.1111/desc.12270

Gerson, S. A., and Woodward, A. L. (2014). Learning from their own actions: the unique effect of producing actions on infants' action understanding. *Child Develop.* 85, 264–277. doi: 10.1111/cdev.12115

Gogate, L. J., Bahrick, L. E., and Watson, J. (2000). A study of multimodal motherese: the role of temporal synchrony between verbal labels and gestures. *Child Develop.* 71, 878–894. doi: 10.1111/1467-8624.00197

Grimminger, A., Rohlfing, K. J., and Stenneken, P. (2010). Do mothers alter their pointing behavior in dependence of children's lexical development and task-difficulty? Analysis of task-oriented gestural input towards typically developed children and Late Talkers. *Gesture* 10, 251–278. doi: 10.1075/gest.10.2-3.07gri

Herberg, J. (2008). Audience-contingent variation in action demonstrations for humans and computers. *Cognit. Sci.* 32, 1003–1020. doi: 10.1080/03640210802022579

Hirai, M., Kanakogi, Y., and Ikeda, A. (2022). Observing inefficient action can induce infant preference and learning. *Develop. Sci.* 25, e13152. doi: 10.1111/desc.13152

Iverson, J. M., Capirci, O., Longobardi, E., and Caselli, M. C. (1999). Gesturing in mother–child interactions. *Cognit. Develop.* 14, 57–75.

Koterba, E. A., and Iverson, J. M. (2009). Investigating motionese: the effect of infant-directed action on infants' attention and object exploration. *Infant Behav. Develop.* 32, 437–444. doi: 10.1016/j.infbeh.2009.07.003

Legerstee, M. (2005). *Infants' Sense of People. Precursors to a Theory of Mind.* Cambridge, MA: Cambridge University Press. doi: 10.1017/CBO9780511489747

Lohan, K. S., Griffiths, S., Sciutti, A., Partmann, T. C., and Rohlfing, K. J. (2014). Co-development of manner and path concepts in language, action and eye-gaze behavior. *Top. Cognit. Sci.* 6, 492–512. doi: 10.1111/tops.12098

Matatyaho, D. J., and Gogate, L. J. (2008). Type of maternal object motion during synchronous naming predicts preverbal infants' learning of word-object relations. *Infancy* 13, 172–184. doi: 10.1080/15250000701795655

Nagai, Y., and Rohlfing, K. J. (2009). Computational analysis of motionese toward scaffolding robot action learning. *IEEE Trans. Autonom. Mental Develop.* 1, 44–54. doi: 10.1109/TAMD.2009.2021090

Nakao, H., and Andrews, K. (2014). Ready to teach or ready to learn: a critique of the natural pedagogy theory. *Rev. Philos. Psychol.* 5, 465–483. doi: 10.1007/s13164-014-0187-2

Pitsch, K., Vollmer, A.-L., Rohlfing, K. J., Fritsch, J., and Wrede, B. (2014). Tutoring in adult-child interaction. On the loop of the tutor's action modification and the recipient's gaze. *Interact. Stud.* 15, 55–98. doi: 10.1075/is.15.1.03pit

Rohlfing, K. J., Fritsch, J., Wrede, B., and Jungmann, T. (2006). How can multimodal cues from child-directed interaction reduce learning complexity in robots? *Adv. Robot.* 20, 1183–1199. doi: 10.1163/156855306778522532

Schober, M. F., and Brennan, S. E. (2003). "Processes of interactive spoken discourse: the role of the partner," in *Handbook of Discourse Processes*, eds A. C. Graesser, M. A. Gernsbacher, and S. R. Goldman (Mahwah, NY: Lawrence Erlbaum Associates), 128–169.

Snow, C. E. (1977). "Mothers' speech research: from input to interaction," in *Talking to Children. Language Input and Acquisition*, eds C. E. Snow, and C. A. Ferguson (Cambridge, MA: Cambridge University Press), 31–49.

Sterelny, K. (2012). *The Evolved Apprentice. How Evolution Made Humans Unique*. Cambridge, MA: MIT Press. doi: 10.7551/mitpress/9780262016797.001.0001

Tabachnick, B. G., and Fidell, L. S. (2001). *Using Multivariate Statistics*. Boston, MA: Pearson/Allyn and Bacon.

Vollmer, A. -L., Lohan, K. S., Fischer, K., Nagai, Y., Pitsch, K., Fritsch, J., et al. (2009). "People modify their tutoring behavior in robot-directed interaction for action learning," in *IEEE 8th International Conference on Development and Learning* (Shanghai: IEEE). doi: 10.1109/DEVLRN.2009.5175516

Wood, D., Bruner, J. S., and Ross, G. (1976). The role of tutoring in problem solving. *J. Child Psychol. Psychiatry* 17, 89–100.

Zukow-Goldring, P. (2006). "Assisted imitation: affordances, effectivities, and the mirror system in early language development," in *From Action to Language*, ed M. A. Arbib (Cambridge, MA: Cambridge University Press), 469–500. doi: 10.1017/CBO9780511541599.015