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Exploring early communicative behaviours: A fine-grained analysis of infant shows and gives

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ABSTRACT

The ability to share and direct attention is a pre-requisite to later language development and has been predominantly studied through infant pointing. Precursors to pointing, such as showing and giving gestures, may display similar communication skills, yet these gestures are often overlooked. This may be due to difficulty in discerning these gestures in interaction. The current study had two aims; firstly, to identify the micro-behaviours associated with showing and giving gestures in infants under 12 months, in order to ascertain whether these form two discrete communicative behaviours. Secondly, to examine whether these micro-behaviours predicted caregiver responses to these gestures. Fine-grained coding of show and give gestures, their micro-behaviours and caregiver responses was conducted through secondary analysis of naturalistic, triadic interactions between 24 infants, caregivers and a selection of toys. Findings suggested that the micro-behaviours arm position, hand orientation and eye-gaze, were significant predictors of infant gesture type, however only arm positioning was a significant predictor of caregiver response. This suggests that early showing and giving gestures can be classified based on some associated micro-behaviours, however caregiver's responses may not be contingent on these same cues, potentially resulting in difficulty understanding infant gestures. Our findings enhance our understanding of infant communication before 12 months, provide guidance to both researchers and caregivers in the identification of infants' early shows and gives, and highlight the need for greater study of these early pre-linguistic behaviours.

1. Introduction

Between 9–12 months, infants experience a transition in their interaction with the world. Systematic patterns emerge in their communicative behaviours as they begin to use deictic gestures combined with eye-gaze, vocalisations, body movements and facial expressions to engage in social interaction with a communicative partner (Bates, 1979; Igualada, Bosch & Prieto, 2015; Liszkowski, Brown, Callaghan, Takada, & De Vos, 2012). The presence of these multimodal communicative behaviours is believed to be an indicator of an infant's joint attention abilities, and a considerable body of evidence links these skills to later language development (Kristen, Sodian, Thoermer, & Perst, 2011; Laakso, Poikkeus, Katajamäki, & Lyytinen, 1999).

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Generally, these early communicative skills have been studied mainly through the pointing gesture (Carpenter, Nagell, & Tomasello, 1998; Cochet and Vauclair, 2010; Tomasello, Carpenter & Liszkowski, 2007). Pointing is perceived as a tool used to initiate joint attention between the infant and adult and pointing declaratively (i.e. pointing with a motive to share or direct attention onto a specific object or event) is a good predictor of later language outcomes (Colonnesi, Stams, Koster, & Noom, 2010; Tomasello et al., 2007). Infants begin to use pointing with a communicative intent at around 11–12 months of age (Fusaroa, Vallotton, & Harris, 2014) and both experimental and non-experimental studies consistently highlight a relationship between this type of pointing and skills in both the production and comprehension of language, particularly verbal naming (see Colonnesi et al., 2010 for a review). Pointing is generally perceived as a landmark communication skill at around 12 months of age (Colonnesi et al., 2010; Liszkowski, 2010).

There is evidence however to suggest that infants can engage in communicative behaviours prior to the emergence of pointing. Bates, Camaioni, and Volterra (1975) found that showing and giving behaviours emerged around 10 and 11 months respectively, whereas pointing with communicative intent did not appear until 12–13 months. The shift from showing and giving to pointing indicates the infant's understanding of the difference between the self and objects. Pointing is believed to be more cognitively complex as it exists outside of the object context and draws attention to more distal referents (Bates, Thal, Whitesell, Fenson & Oakes, 1988). However, both showing and giving behaviours also reflect the ability to initiate joint attention and demonstrate an understanding that the adult is an agent separate from the environment and capable of engaging with an object. Support for the claim that shows and gives are precursors to pointing is presented in Cameron-Faulkner, Lieven, Theakson, & Tomasello (2015). In their study of 10–12 month old infants, shows and gives emerged prior to pointing behaviours and also had a strong association with the later use of points but not reaches (the latter of which are associated with imperative behaviours and are not deemed to be as cognitively complex in nature). Beuker, Rommelse, Donders & Buitelaar (2013) examined the developmental trajectory of specific joint attention skills and their interrelations with later vocabulary size. They found that infants who developed joint attention skills at an earlier age, specifically gestures which involved directing attention (such as showing, giving and pointing) displayed larger receptive and expressive vocabulary growth earlier in life. Thus, showing and giving gestures may be good candidates for studying the foundations of early communication and the skills that make us uniquely human.

To date pre-linguistic showing and giving behaviours have been under-researched, particularly when compared to studies on pointing. A potential reason for this absence is the lack of a clear definition of the two constructs. Bates et al. (1975, 1976) highlighted the difficulty in distinguishing showing and giving behaviours, suggesting that their function is often ascertained by how others react to the social context and that often, infant intentions are misinterpreted by caregivers. They referred to shows and gives as an extension of the arm towards the adult and distinguished between the two behaviours based on whether the infant gave the toy to the adult or kept it for themselves. Clements and Chawarska (2010) built on these definitions in their study of shows, gives and points in 9 and 12 month olds with autism. Shows were defined as "a person's arm extending toward another person's face while holding an object" (p. 48) whereas giving behaviours were described as "placing an object in another person's hand or pushing an object at least halfway toward another person" (p. 48). Even with these more detailed definitions, the authors noted that pointing gestures were more salient than showing gestures due to their specific hand form (i.e. an outstretched arm with the index finger extended).

The lack of salience of many showing gestures creates problems from a methodological viewpoint. Typically, naturalistic research on gesture development is conducted through observation or parental diaries. Although this provides an ecologically valid measure of infants' spontaneous gestures (Capirci, Iverson, Pizzuto & Volterra, 1996; Woodward, 2009, Crais, Douglas, and Campbell (2004) highlighted the concern researchers often have over parental report methods, (i.e. through parental diaries) as the reliability of their interpretations is questioned. Whilst researchers may be trained to recognise behaviours in infants, parents may find it difficult to recognise "researcher defined" gestures or their functions, potentially jeopardising the validity of communicative development research (Woodward, 2009). The difficulty in identifying these gestures extends to caregivers in the home environment too. Bates et al. (1975, 1979) highlighted the problem of caregivers misinterpreting these gestures as instrumental acts or overlooking this action completely. Early pointing studies have already established that children rely on verbal feedback to determine connections between their pointing gestures and intentions, and adults who respond promptly, contingently and appropriately to infant actions tend to improve infants' subsequent production and comprehension of words (Colonnesi et al., 2010; Rowe & Goldin-Meadow, 2009). Furthermore, observation of the responses of others facilitates not only social learning, but enables the understanding of intentional communication (i.e. awareness of other people's goals during interaction) which plays a fundamental role in language development (Elsner, Bakker, Rohlfing, & Gredebäck, 2014).

Theoretically, being able to distinguish these gestures would provide greater insight into the emergence of intentional communication in pre-linguistic infants. Towards the end of their first year, infants' communicative competencies increase and they begin to use gestures with a number of accompanying behavioural characteristics, such as systematic hand shapes and vocalisations, to help more directly express their social intentions. Exploration of these behaviours could provide insight into the different motives underlying early pre-linguistic gestures. It would also help determine whether these gestures are fully ambiguous and so interpretable only from the context of the shared interaction and preceding actions. The difficulty in pinpointing infant intentions outside of adults' responses raises the question of whether infants formulate an intention before they hold out a toy, or if their behaviours are contingent on the adult's response. If this were the case, it may be impossible to distinguish between early showing and giving gestures without relying on caregiver feedback. If, however, in a typical interactional context, shows and gives involved distinct behavioural cues (e.g. a particular hand position) it would

allow for greater examination of the role of caregiver responses in forming and developing these gestures (Bates et al., 1975; Liszkowski, 2005). Identifying and understanding these behavioural cues is an important step in the understanding of the origins of language and social cognition in humans.

Research on the pointing gesture has managed to overcome the issue of ambiguity to some extent by providing objective associated micro-behaviours to help study the development of this gesture in greater detail (Bates et al., 1975; Brooks & Meltzoff, 2008; Cochet & Vauclair, 2010; Gullberg, de Bot, & Volterra, 2008; Krause & Fouts, 1997; Liszkowski, Carpenter, & Tomasello, 2008; Woodward, 2009). Cochet et al. (2014) used a frame by frame video analysis to describe the differences between infant's early pointing gestures versus reaching. Features such as arm extension, hand-shape and body posture were all found to demonstrate different functions of infants' gestures. Arm extension was found to be greater with pointing gestures, and these were often accompanied by an outstretched index finger. In contrast, infants leaned further forward when reaching whereas pointing was characterised by a 'sitting back' posture (Lock et al., 1990). A number of other studies have looked at the impact of vocalisations and gaze alternation on early social interaction and language development (Franco & Butterworth, 1992; Grünloh & Liszkowski, 2015; Liszkowski & Tomasello, 2011). Infants tend to produce different types of vocalisations when they are engaged in social interaction compared to when they are alone (Goldstein, Schwade, Briesch, & Syal, 2010). Furthermore, vocalisations are more likely to accompany declarative pointing gestures compared to imperative reaching (Grünloh & Liszkowski, 2014). These differences suggest that declarative, communicative gestures are more closely interconnected to the vocal system and thus later language development (Cochet & Vauclair, 2010). The co-occurrence of gaze alternation with a gesture is often considered evidence of intentional communication (e.g. Cochet & Vauclair, 2010; Franco & Butterworth, 1996). Previous studies have found that gaze alternations with pointing were produced more frequently in a declarative context, particularly one that requested information (Cochet & Vauclair, 2010).

All of these micro-behaviours provide a number of important developmental functions; they are a means of expressing infants' intentions and feelings, they help engage a social partner in interaction and allow infants to display their affective experiences (Bates et al., 1975; Bates, 1979). They also provide quantitative measures to allow researchers to categorise different gestures and clarify differences based on various features. To our knowledge, these precise definitions for coding have not been looked at for early showing and giving gestures. Exploration of the associated micro-behaviours of showing and giving would allow researchers to examine these gestures to the same extent as pointing and reaching, and could provide parents with information to aid in their identification of these early gestures.

The current study addresses this gap in the literature by conducting a fine-grained analysis of these early communicative gestures in naturally-occurring play, documenting early showing and giving, their associated micro-behaviours and caregiver responses to these gestures. The study has two specific research aims: Firstly, to examine whether shows and gives are two distinct behaviours by documenting associated micro-behaviours. From this we would hope to provide standardised behaviour codes to help identify and distinguish between these gestures. Secondly, to examine whether caregiver's responses are predicted by the patterns of micro-behaviours associated with infants' gestures. From this we hope to examine whether caregivers' linguistic and non-linguistic responses to infants' gestures are contingent on specific infant micro-behaviours displayed when they gesture.

2. Method

2.1. Dataset

The data from the current study was taken from pre-existing video corpus of pre-linguistic interaction between infants aged 10–13 months and their caregivers. The data was collected as part of a larger, longitudinal study on the emergence of proto-declarative gestures (Cameron-Faulkner et al., 2015).

2.2. Participants

24 infants (10 girls: mean age 313 days, range 267–356 days) and their mothers were recruited from the centre database at the University of Manchester Child Study Centre. All dyads were monolingual English-speakers from the north-west of the UK with no reported language delay. Families that participate at our Study Centre typically come from middle class backgrounds, though demographic information was not collected for the current study. The mothers were given travel expenses and the children were presented with a book for their participation.

2.3. Procedure

Infants had to attend three monthly sessions which took place within a controlled environment in a child study lab. Two video cameras were used to capture the body movements and facial expressions of both the infants and caregivers. Infants engaged in 20–25 min of natural free-play sessions with their caregiver and a selection of age-appropriate toys (e.g. plastic cups, rattles, blocks, brushes etc.) with a variety of shapes, sizes and textures, supplied by the experimenter. All toys were picked with the aim of eliciting a declarative motive (i.e. a motive to share attention and interest) rather than an imperative. Specifically, all toys could be fully manipulated by the infants without requiring any assistance from the caregiver. The naturalistic play sessions were also established to encourage sharing interest in the toys and in terms of the target object

Table 1
Codes for infant behaviour taken from the original coding scheme.

Gestures	Definition
Shows	Infant holds up object in the view of the co-participant.
Gives	Infant hands over object to the mother in one action (i.e. no prompt from co-participant).

NB: Gestures were only coded if they were triadic (i.e. involved the infant, co-participant and toy) and were initiated by the infant.

Table 2
Selection of codes, levels and definitions used to code associated behaviours of shows and gives.

Variables identified	Coding classification levels	Definition
Vocalisation	Yes	Gestures are accompanied by vocalisation by the infant
	No	Gestures are not accompanied by vocalisation by the infant
Eye gaze location	Eye gaze to hearer (EGH)	Infant's look primarily to caregiver when displaying a gesture
	Eye gaze to object (EGO)	Infant's look primarily to the toy when displaying a gesture
Gaze alternation	Yes	Evidence of gaze alternation during the infant's gesture
	No	No evidence of gaze alternation during the infant's gesture
Hand orientation	Palm down (PLM-DWN)	Gesture displayed with palm facing down towards the floor
	Palm up (PLM-UP)	Gesture displayed with palm facing up towards the ceiling
Infant arm level	Arm level raised (ARM-UP)	Infant raises the arm with the toy upwards.
	Arm straight (ARM-SRT)	Infant holds the arm with toy straight out towards caregiver
Infant posture	Lean forward (LN-FWD)	Infant leans towards the caregiver.
	Lean backwards (LN-BWD)	Infant leans away from the caregiver.

behaviours. Infants and caregivers sat on the floor on a play rug without other distractions around them. Caregivers were asked to let their infants lead the play so that the maximum amount of infant initiated behaviours could be elicited.

Sessions were divided into two 10 min phases. During phase 1, the experimenter left the room and the infant and caregiver were recorded playing together. At the end of phase 1, the experimenter returned to the room, collected the toys, and replaced them with a different selection of toys. Phase 2 repeated the social play session but with the new toys. Infants participated in these sessions once a month for 3 months. Each session was the same duration and had the same procedure.

2.4. Coding and reliability

2.4.1. Gestures

All coding was conducting using the video recordings of the original larger study (Cameron-Faulkner et al., 2015). For the original study, two trained research assistants coded the data for instances of infant showing and giving gestures based on the definitions in Table 1, as well as infant reaches and points. The coding criteria for shows and gives were broad and did not include any specific detail on the more fine-grained aspects of the gestures. The two research assistants were blind to the hypotheses of the original study. In addition to coding the infant gestures, the research assistants also categorised the interactional sequences following each instance of these communicative behaviours (i.e. shows, gives, reaches and points) with respect to eye gaze and object manipulation or maternal comment. For the current study, the first author began by recoding the data using the same broad definitions of show and gives as used in the larger study. These codes were then compared with those of the original study. We examined whether the current and previous coders identified the same behaviours as infant initiated show and give behaviours. Of the 112 instances identified by either coder, agreement was $k = 0.70$ (79%). Behaviours which could not be agreed upon were labelled ambiguous and removed from subsequent analyses. Of the 92 instances of communicative gestures identified by both coders, agreement was $k = 0.76$ (87%) for type of gesture (a show vs. a give) indicating good reliability between the categorisation of the original coders and the first author. Following the initial identification phase we established a coding scheme for the micro-behaviours by drawing on existing studies of prelinguistic communicative behaviour (see below). For each infant, only the first session to display shows and gives was coded, as we were interested in the earliest display of these gestures. The type of gesture was categorised using binary codes of 1 for a showing gesture and 0 for a giving gesture.

2.4.2. Micro-behaviours

The first author established a coding scheme for potentially relevant micro-behaviours. Micro-behaviours were selected based on previous codes used for the classification of more established gestures such as points and reaches (e.g. Brooks & Meltzoff, 2008; Cochet & Vauclair, 2010; Elsner et al., 2014). Table 2 displays the micro-behaviours coded for each show and give. The video-recordings were then re-examined and the micro-behaviours for each identified communicative gesture were coded. The micro-behaviour analysis was conducted on the data after a sufficient time lag from the identification phase and in addition the show/give categorisation was hidden. Also all show and gives which were identified during both the original and current study (as mentioned above) were included in the analysis.

Table 3
Codes used to document caregiver responses to infant shows and gives.

Caregiver behaviour	Definition	Behaviour	Non-linguistic example	Linguistic example
'Show' response	Caregiver responds in a way that is appropriate for an infant's showing gesture.	Looks to the object and/or comments on it.	Eye gaze focuses on both toy and the infant. No attempt to reach for the toy.	"*Yes it's a red one*" "*Cups! Do you like the cups?*"
'Give' response	Caregiver responds in a way that is appropriate for an infant's giving gesture.	Reaching/grasping toy and/or comments on it.	Caregiver reaches out for toy and eye-gaze is mainly focused on the toy.	"*Is that for me?*" "*Thank you*"
Ignore	Caregiver fails to respond contingently to the infant's gesture.	No eye-gaze or attention on the toy of interest and no/non-contingent comment.	Caregiver ignores toy of interest and eye gaze is located elsewhere in the room.	"*We have to get a train later*" "*Oh it's lovely and sunny outside!*"

2.4.2.1. Vocalisation. Vocalisation was scored as a binary code of 1 if the gesture was accompanied by vocalisation and 0 if it was not. These codes were then compared to the original coding. Agreement for this behaviour with the previous coding was good $k = 0.73$ (84%).

2.4.2.2. Eye gaze. Eye gaze was coded as 1 if the infant looked to the caregiver first when displaying a gesture and 0 if they primarily looked at the toy. Again these codes were compared to the coding from the original study. Coders agreement for the location of eye-gaze was $k = 0.64$ (66%) indicating moderate reliability. Similarly gestures that were accompanied by gaze alternation were scored as 1 if there was evidence of gaze alternation and 0 if the eye gaze was fixed, agreement between coders was again good $k = 0.78$ (81%).

2.4.2.3. Morphological features. Arm positioning was given a code of 1 if the arm was raised and 0 if it was straight out/lowered slightly. Body posture was given a code of 1 if the infant leaned forward and 0 if they did not move. Hand-orientation was split into "inverted" hand-shape (i.e. palm facing downwards) and "upwards" hand-shape (i.e. palm facing up or towards the caregiver) as these had been suggested in past literature as indicators of infant gives (Elsner et al., 2014). Codes which were difficult to define due to camera angles or the positioning of the dyads were coded as ambiguous.

2.4.3. Caregiver responses

Caregiver linguistic and non-linguistic responses to infants' shows and gives were classified. These definitions were based on codes used in the larger study which in turn were based on pre-established categories used in the classification of caregiver contingent talk and follow-in behaviour towards infant's gestures (Cameron-Faulkner et al., 2015; McGillion et al., 2013; Tomasello & Farrar, 1986). Table 3 displays the caregiver responses coded for each show and give gesture. These responses were split into 'show' responses (look and comment contingently on the object) and 'give' responses (reaches towards toy and asks for it). Caregiver responses were given a score of 1 for a perceived 'show' response and 0 if it involved for a perceived 'give' response. Agreement between coders for caregiver's non-linguistic responses was $k = 0.85$ 'Ignore' responses from the caregivers were also coded whenever they failed to respond linguistically and non-linguistically to the infants' target gestures.

2.5. Analysis

To examine whether the observed micro-behaviours were linked to (1) categorisations of infant gesture type, and (2) caregivers' interpretations of these gestures, a multiple correspondence analysis, followed by a mixed-effects logistic regression was performed in R (R Core Team, 2012). Results are organised as follows. Firstly, descriptive statistics are presented for the proportion of infant showing and giving behaviours, the associated behavioural cues and caregiver interpretations of these gestures across the selected sessions. Secondly, the graphical results of the multiple correspondence analyses are displayed and described. Finally, the mixed-effects logistic regression is reported for both infant gesture classification and caregiver response outcomes.

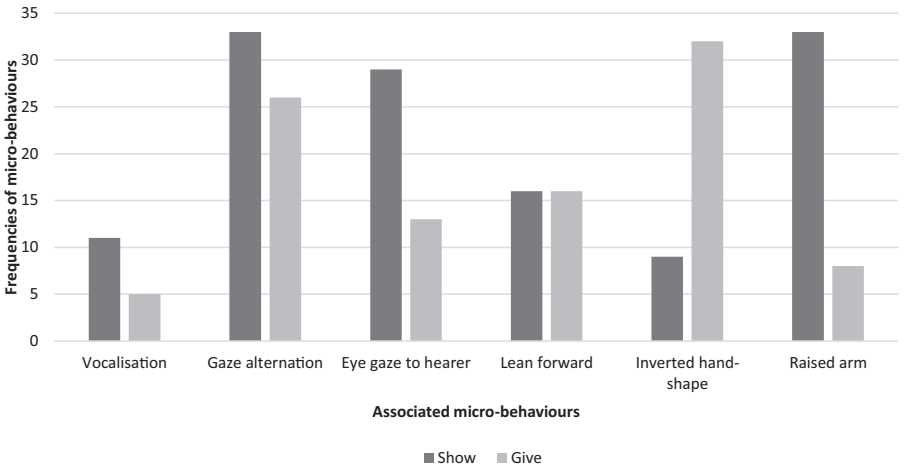

Fig. 1. Frequencies of micro-behaviours associated with infants' shows and gives.

3. Results

3.1. Frequencies of shows, gives and associated micro-behaviours

Overall, 20 participants displayed some form of showing or giving in at least one of their three sessions. Four participants were excluded due to a lack of shows and gives. There were a total of 92 episodes of gesturing across all participants. Of these 54% were classified as shows (n = 50) and 46% were labelled as gives (n = 42). There were instances of individuals who displayed only shows or only gives in their session. Infants produced an average of 2.5 shows (range: 0–8) and an average of 2 gives within their sessions (range: 0–10). Age of first use of gestures was not significantly correlated with overall number of showing and giving gestures produced ($r = -0.1$; $p = 0.3$) nor was it correlated with the type of gesture produced ($r = -0.04$; $p = 0.7$). This suggests that the age of onset for these gestures within these sessions did not predict the frequency of gestures or the type of gesture.

Vocalisation accompanied just 17% of infants' gestures whereas gaze alternation was present with gestures on average 64% of the time. Infant gaze focused primarily on the caregiver 46% of the time. Regarding the form of the gestures, 35% of gestures were characterised by the infant leaning forward and 45% of gestures displayed an 'inverted' hand-shape compared to a 'palm up' hand orientation. Gestures with a raised arm, as opposed to a straight out position also accompanied 45% of infants' gestures. Fig. 1 displays the frequencies of the associated behaviours for both infant shows and gives. When broken down, there were clear differences in the numbers of these behaviours for infants' showing vs. giving.

3.2. Multiple correspondence analysis: associations between gesture categorisations, micro-behaviours and caregiver responses

To visually examine the pattern of relationships of the variables, a Multiple Correspondence Analysis (MCA) was conducted using the FactoMineR function in R (R Core Team, 2012). Firstly, we looked at associations between the micro-behaviours and the researcher classified shows and gives. Fig. 2 displays clusters for the micro-behaviours and the showing and giving gestures. Two fairly clear clusters of associations are apparent. In the top left quadrant, the behaviours classified as 'show' are highly associated with a 'palm up' hand position and a raised arm. In the bottom right quadrant, the behaviours classified as 'give' are highly associated with a 'straight arm' position and 'inverted hand' shape.

We then looked at the associations between the micro-behaviours and caregivers' responses to infant gestures (see Fig. 3). Again, there are two clusters, however these are not as distinct compared to the researcher's classifications of infants' showing and giving in Fig. 2. In the top left quadrant, both non-linguistic and linguistic responses classified as 'show responses' are clustered near to the 'palm up' hand position and a raised arm. In the bottom right quadrant, both non-linguistic and linguistic responses classified as 'give responses' are clustered near to the 'straight arm' position but actually are most closely associated with the infant's lack of vocalisations. Furthermore, although these responses are positioned in the same quadrant as the researcher's classifications of shows and gives, they are not as closely associated, suggesting a level of ambiguity when interpreting these gestures.

3.3. Regression model 1: behavioural cues and infant gestures

We then carried out two analyses to investigate whether these micro-behaviours significantly predicted (1) the classification of infants' gestures and (2) caregivers' linguistic and non-linguistic responses.

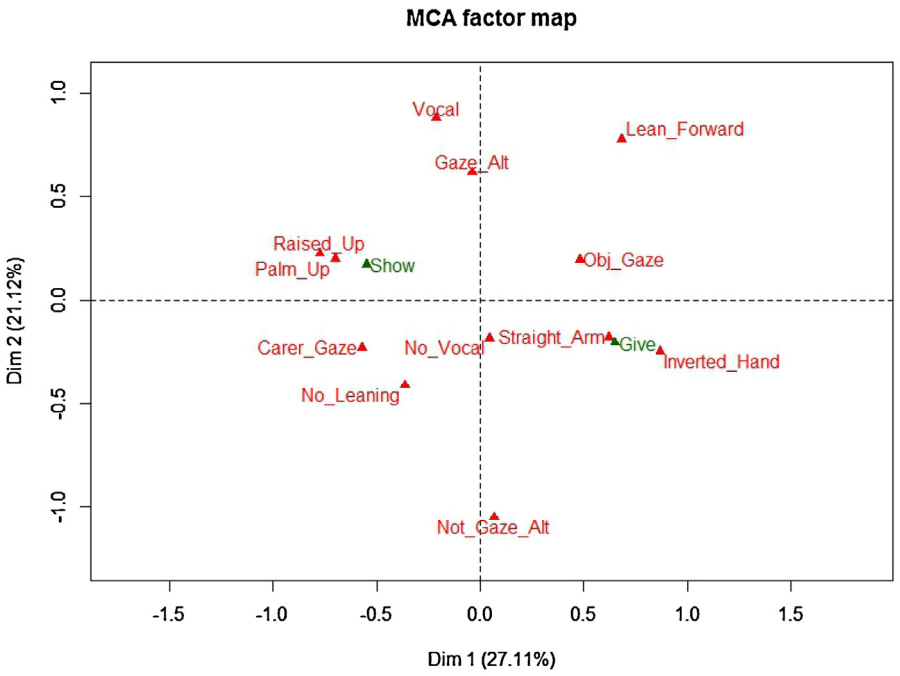

Fig. 2. Multiple correspondence analysis with contribution behaviour, gaze alternation, eye gaze location, vocalisation, arm position, hand orientation, posture.

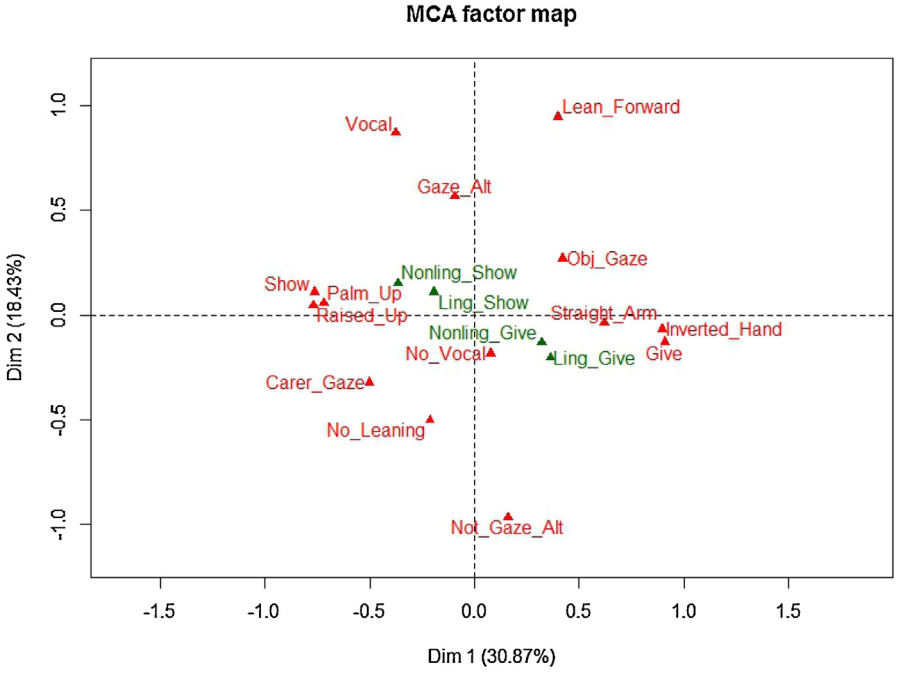

Fig. 3. Multiple correspondence analysis with contribution gaze alternation, eye gaze location, vocalisation, arm position, hand orientation, posture, caregiver linguistic response and caregiver non-linguistic response.

Regression models were fitted using the lme4 function in R (Bates, Maechler & Bolker, 2012) with the two outcome variables; gesture (show vs. give) and caregiver response (show response vs. give response) used in two separate models. The following predictor variables; 'vocalisation', 'gaze alternation', 'eye-gaze to caregiver, "arm raised", 'inverted hand-shape' and 'lean forward' were entered as fixed effects and 'participants' and 'age of first use' as a random intercept effects. Overall fit of the model was tested using a likelihood ratio test, comparing the models with predictor behaviours entered to a baseline model (with no effects of interest) (Field et al., 2012).

Table 4
Parameter information for model 1, with associated behavioural cues as predictors.

Parameters			
Fixed effects	Coefficients	*SE*	*p value*
Intercept	0.47	0.11	<0.001*
Inverted hand shape	−0.33	0.09	<0.001*
Infant leans forward	−0.06	0.09	0.8
Infant raised arm	0.34	0.08	<0.001*
Vocalisation	0.09	0.12	0.4
Eye gaze to hearer	0.19	0.09	0.03**
Gaze Alternation	−0.05	0.08	0.6

* Statistically significant at $p < 0.001$ level.
** Statistically significant at the $p < 0.05$ level.

Table 5
Parameter information for model 4, with all behavioural cues entered.

Parameters			
Fixed effects	Coefficients	*SE*	*p value*
Intercept	0.47	0.13	0.008**
Inverted hand shape	−0.16	0.11	0.14
Infant leans forward	0.2	0.12	0.6
Infant raised arm	0.33	0.11	<0.001*
Vocalisation	−0.16	0.14	0.3
Gaze Alternation	−0.11	0.1	0.3
Eye gaze to hearer	−0.12	0.11	0.3

* Statistically significant at $p < 0.001$ level.
** Statistically significant at the $p < 0.05$ level.

Before considering the main predictor variables of interest, we compared models with and without the random effect of age of first use. The addition of infant age did not provide a significantly better fit to the data (χ^2 (1) = 0.92, p = 0.6) thus only 'participant' was retained to control for differences accounted for by individuals. Consequently, model 1 included all of the predictor variables to establish if any of the infant micro-behaviours were significant predictors of the categorisation type (show/give) assigned to infants' gestures. Model 1 was then compared to a baseline model without the predictor variables to assess the fit of the data. Table 4 displays the coefficients and standard error results for all the micro-behaviours entered into model 1.

The results showed that gaze alternation, infant posture and infant vocalisation were not significant predictors of the classification of infant gesture. In contrast, the location of infants' eye-gaze significantly predicted gesture type classification, as eye-gaze primarily directed to the caregiver was associated with infant showing gestures. 'Inverted' hand-shape was also found to have a significant, negative association with infant showing, indicating that it was a significant predictor of infant gives. Likewise, in positioning was found to be a significant predictor of gesture type, as a raised arm was associated with infant showing. 'Inverted' hand-shape was found to have a significant, negative association with infant showing, indicating that it was a significant predictor of infant gives. When comparing model 1 to the baseline model, the predictive behaviours significantly improved the fit of the model (χ^2 (9) = 53.0, $p < 0.001$). This suggests that there are specific micro-behaviours associated with each global behaviour type.

3.4. Regression model 2: behavioural cues and caregiver responses

To test whether caregivers' linguistic and non-linguistic responses to infant gestures were also predicted by the micro-behaviours present with the infants' gestures, a further mixed effects logistic regression was conducted, with caregiver response (show response, characterised by shared orientation and comment vs. give response, characterised by reaching for and/or requesting the toy) as the outcome variable. Again, the inclusion of infant age as a random effect within the model did not provide a significantly better fit to the data (χ^2 (1) = 0.05, p = 0.9) thus only 'participant' was retained to control for differences accounted for by individuals. Model 2 again included the following predictor variables; 'vocalisation', 'gaze alternation', 'eye-gaze location' (eye-gaze to hearer) 'arm positioning' (raised arm), 'hand orientation' (inverted hand-shape) and 'body posture' (lean forward) as fixed effects and 'participants' as random intercept effects. Again, fit of the model was obtained by likelihood ratio tests, comparing model 2 (with the predictors of interest) to a baseline model (with no effects of interest). Table 5 displays the coefficients and standard error results for vocalisation, gaze alternation and all the other behavioural cues entered into model 2.

Like the previous model, vocalisation, gaze alternation and infants' posture changes were not significant predictors of the type of caregiver response to infant gestures. However, infants' eye-gaze was also not a significant predictor of caregiver

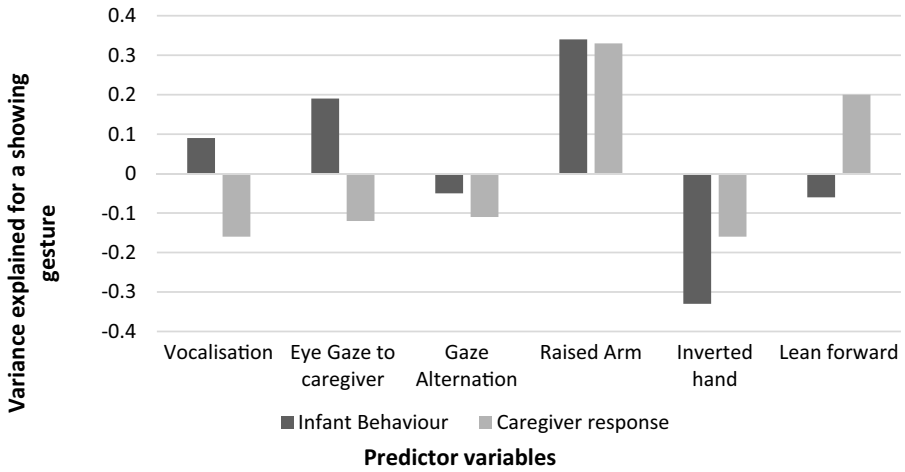

Fig. 4. Summary of coefficient values displaying variance in infant's behaviours and caregiver responses explained by different predictors.

responses. Infants' hand-orientation also did not reach statistical significance indicating that infants' body, hand-shape, vocal and visual behaviours were not predictors of caregiver's responses.

Arm positioning was again found to be a significant and indeed the only predictor of caregiver responses, with a raised arm displaying a significant and positive association with caregiver's shared orientation and comment (show response). When comparing model 2 to the baseline model, the predictive behaviours significantly improved the fit of the model (χ^2 (9) = 17.34, p = 0.008). Fig. 4 displays a summary of the variance explained by each predictor for both infant behaviour classifications (show vs. give) and caregiver responses (show response vs. give response). Positive values indicate a stronger association with behaviours classified as shows/caregivers' shared orientation/commenting (show responses) whereas negative values imply a greater association with infant behaviours classified as gives/caregivers' reach/request (gives responses) behaviour.

4. Discussion

This study set out to address the gap in the literature concerning infants' early showing and giving gestures, by conducting a fine-grained analysis of these gestures and their associated micro-behaviours. The aims of the study were (1) to investigate both showing and giving gestures in infants and to characterise them in terms of vocalisation, hand-shape, arm and body position, eye gaze location and gaze alternation (2) to investigate the predictive value of these micro-behaviours on caregivers' responses to infant gestures. We used naturalistic video-data from a larger study to identify instances of showing and giving, the associated micro-behaviours and caregiver responses. Our results suggest a distinction between the micro-behaviours associated with showing and giving gestures and also a contrast in the predictive value of these behaviours for researcher classifications of these gestures compared to caregiver responses. Below we discuss some of the key findings and areas for future study.

4.1. The type of gesture was not associated with age

The current findings support the view that from 9 to 10 months, infants begin to use gestures as a way to communicate and interact with a social partner (Bates, 1979; Cameron-Faulkner et al., 2015; Cochet & Vauclair, 2010;). Overall, 83% of the infants demonstrated evidence of self-initiated shows and gives which displayed some evidence of communicative function (i.e. a motivation to share attentions and interest). Interestingly, the age of onset for these behaviours did not significantly predict the overall number of shows and gives observed or the type of gesture produced. A possible explanation for this is that before 12 months, infants are still learning how their gestures can achieve specific communicative goals and so do not yet use them consistently within social play (Carpenter et al., 1998). If this was the case, it is possible that the type of gesture produced at this stage may be contingent on the caregiver's response rather than a previously formulated intention. Indeed, our findings revealed that individual infants often displayed a tendency to use one type of gesture over the other during the social play session.

The identification of specific micro-behaviours for shows versus gives provides researchers with the opportunity to analyse the earliest instances of these gesture and examine how each is shaped by caregiver responses.

4.2. Vocalisation and gaze alternation were not significant predictors of infant shows or gives, however eye-gaze location was

Vocalisation only accompanied 17% of infants' gestures and was not a significant predictor of gesture type. A possible explanation for this is that the infants in our study were still quite young to be consistently vocalising as a means of

communication. Gros-Louis & Wu (2012) noted an increase in pointing gestures and vocalisation only after 12 months of age, and also found that infants produced vocalisations concurrently with gestures to orient the adults' attention to the object. In our study, the adults were generally attentive to the infant throughout the interaction, which may have decreased the need for vocalisation when the adult was not attending. Further research is required to determine whether caregiver's attentional focus dictates the frequency and type of vocalisation with showing and giving gestures, and to explore the developmental trajectory of this behaviour into the infants' second year.

Gaze alternation was also not a significant predictor of showing or giving, although it accompanied a higher proportion of gestures (64%). A possible explanation for this is that gaze alternation highlights the presence of general intentional communication rather than acting as a predictor of the type of gesture displayed. Research consistently highlights the presence of gaze alternation in conjunction with gestures such as giving, showing, reaching and pointing (Bates et al., 1975; Cochet & Vauclair, 2010; Gros-Louis, West & King, 2014). However, previous studies have noted that gaze alternation is often not a reliable predictor of infant communicative intentions and often can be influenced by the specific contexts in which the child was recorded (Cameron-Faulkner et al., 2015; Liszkowski & Tomasello, 2011). Clearly, the relation between the use of eye gaze to direct attention, and its relation to specific communicative behaviours and developments requires greater clarification, and so the conclusions we can draw from this behaviour should be interpreted with caution.

Interestingly, although gaze alternation did not significantly predict the type of gesture used by infants, eye-gaze location did. Infant eye-gaze to the caregiver was associated with a showing gesture. Previous studies have suggested that early pointing in infants emerges from a shared practice of looking at things with a social partner (Liszkowski & Tomasello, 2011). Pointing with communicative intent is generally accompanied by visual checking, particularly eye gaze to the caregiver, to establish common ground (e.g. Dimitrova, Moro, & Mohr, 2015; Haynes et al., 2004). The significant association between eye-gaze to the caregiver and the showing gesture supports the idea that this gesture may be a precursor to communicative pointing, and reflect a similar motive to share that interest and attention with others (Liszkowski, Carpenter, Henning, Striano, & Tomasello, 2004; Tomasello et al., 2007). The presence of this behaviour alongside early infant showing gestures could provide greater insight into the developmental trajectory of pre-linguistic communication.

4.3. Arm positioning and hand-shape were significant predictors of infants' shows and gives

Differences in arm position were a significant predictor of infant gesture categorisation; a raised arm was more frequently associated with a showing gesture than a giving gesture. This is an interesting finding as although arm positioning has been used to define pointing and reaching gestures (e.g. Franco & Butterworth, 1996) the relationship between this behaviour and other deictic gestures has yet to be studied in great detail. Another interesting observation was the significance of hand-shape variability in predicting infant gesture categorisation; an 'inverted' hand-shape was more frequently associated with a giving gesture. Previous studies suggested that hand-shape variability was a significant indicator of infants' motives when pointing at an object or event (e.g. Brooks & Meltzoff, 2008; Franco & Butterworth, 1996) and a recent study reported that infants as young as 12 months displayed abilities to differentiate between goal-directed gestures based on their hand-shape (Elsner et al., 2014). Replication of the current findings (i.e. that a raised arm is a significant predictor of infant showing gestures whereas an inverted hand-shape helps predict the likelihood of a giving gesture) could establish these as salient indicators of shows and gives and aid in their identification in both research and social situations.

4.4. Caregiver responses were not contingent on infants' behaviours, with the exception of arm position

From our initial observations, it seemed that caregivers sometimes found it difficult to understand their infant's gestures, for example responding to the infants with a question like "Is that for me?" when the infant held out a toy. This suggests that at this age, the intent of infants' emerging gestures is sometimes unclear to the recipient. This assumption would support the recent finding of Dimitrova et al. (2015) who also found that the communicative status of prelinguistic gestures was often overlooked or misinterpreted by caregivers. Our second aim was therefore to investigate whether caregiver responses were contingent on infants' micro-behaviours displayed when gesturing. Caregivers responses were divided into 'show' responses (looks and/or comments) and 'give' responses (extends hand and/or asks for toy) to the infants' gestures (Cameron-Faulkner et al., 2015).

With the exception of arm position, none of the behaviours produced by the infants significantly predicted the likelihood of particular caregiver responses. Rather than concluding that these behaviours have little relevance, one possibility is that there are complex multimodal interactions between the various behavioural cues that influence their interpretation. For example, it could be that infant vocalisations have particular significance that is contingent on the presence or absence of shared eye contact with the caregiver. To examine these more complex interactions, a much larger sample of infant show and give behaviours would be needed. Although further work is needed to investigate possible interactions between cues and caregivers' abilities to utilise this information to interpret infant gestures, one additional cue was predictive of researcher categorisations of infant behaviours. Thus, there is still the possibility that the lack of significant associations between infant micro-behaviours and caregiver responses can be explained by caregiver failure to utilise all the available behavioural cues produced by the infant (Cochet & Vauclair, 2010). A number of studies indicate that when an infant uses clear communicative cues during a joint attention episode, the caregiver provides more contingent responses overall (Vallotton, 2009). This sharing of information helps the infant to gain an understanding of their social world and adults who respond

contingently to infant gestures aid in the advancement of their social and language repertoire (Colonnesi et al., 2010). The current study provides a set of standardised behaviours to help identify showing and giving gestures not only for research purposes, but to inform caregivers in the home about the presence of infant behavioural cues during social interaction. This is a first step in the investigation of caregiver responsiveness to these early gestures and the potential factors that may influence this contingency.

5. Conclusions

Taken together, the results of this study provide valuable insight into infants' communicative patterns before 12 months and question the assumption that infant pointing is the first communicative milestone achieved (Colonnesi et al., 2010; Liszkowski, 2010). Infants' showing and giving gestures display evidence of differing behaviours and demonstrate infants' ability to initiate these early gestures during triadic play, engaging the adult in the object of interest. This ability to adapt their behaviours may reflect earlier instances of communicative intentions, and the emergence of more sophisticated communicative abilities (Liszkowski, 2010). The research calls for future studies to explore these gestures and associated behavioural cues using more controlled experimental methods and longitudinal studies, to further determine their significance as a window onto infants' intentional communication and to explore the relationship between early showing and giving gestures and later language acquisition. Furthermore, the current findings highlight the need for researchers to focus on a number of features in infant gesture, including arm positioning, hand shape, and eye-gaze reference when coding infants' early shows and gives, in order to fully ascertain the functions of early communicative gestures. Clear documentation of behavioural cues associated with early shows and gives may not only aid in parental reports of infants' gestures, but generally provide parents with clearer indications of their child's intentions, potentially reducing the number of misinterpretations, which could be beneficial to both infant language development and social interaction (Dunham & Dunham 1992).

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