Infant and Child Development
Inf. Child Dev. **15**: 161–177 (2006)
Published online in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/icd.446

Learning from Others in 9–18-Month-Old Infants

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The use of an adult as a resource for help and instruction in a problem solving situation was examined in 9, 14, and 18-month-old infants. Infants were placed in various situations ranging from a simple means-end task where a toy was placed beyond infants' prehensile space on a mat, to instances where an attractive toy was placed inside closed transparent boxes that were more or less difficult for the child to open. The experimenter gave hints and modelled the solution each time the infant made a request (pointing, reaching, or showing a box to the experimenter), or if the infant was unable to solve the problem. Infants' success on the problems, sensitivity to the experimenter's modelling, and communicative gestures (requests, co-occurrence of looking behaviour and requests) were analysed. Results show that older infants had better success in solving problems although they exhibited difficulties in solving the simple means-end task compared to the younger infants. Moreover, 14- and 18-month-olds were sensitive to the experimenter's modelling and used her demonstration cues to solve problems. By contrast, 9-month-olds did not show such sensitivity. Finally, 9-month-old infants displayed significantly fewer communicative gestures toward the adult compared to the other age groups, although in general, all infants tended to increase their frequency of requests as a function of problem difficulty. These observations support the idea that during the first half of the second year infants develop a new collaborative stance toward others. The stance is interpreted as foundational to teaching and instruction, two mechanisms of social learning that are sometime considered as specifically human.

Key words: infancy; problem solving; communicative gestures; teaching; collaboration

Social factors and social learning have been a lesser focus for researchers and theorists interested in early cognitive development. Infants are typically observed

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while exploring and trying to solve a practical problem on their own, without the help or any instruction from others (Piaget, 1952; Willatts, 1990; McCarty *et al.*, 1999). While research with older children demonstrates how interactions with others facilitate problem solving through guided participation and scaffolding (Vygotsky, 1978; Rogoff, 1990), few studies have focused on how social factors might guide infants as they start to solve practical problems such as reaching for and retrieving objects.

Young children acquire skills by observing and emulating people around them (Mosier and Rogoff, 1994). Studies on imitation, while typically not geared toward problem solving, demonstrate that by the end of the first year, infants are good imitators of actions or gestures they see performed on objects by others. These imitations can be immediate (Barr *et al.*, 1996; Provasi *et al.*, 2001), but also deferred in time (for a review see Meltzoff, 1996), and pertaining to novel gestures on novel objects (Meltzoff, 1988; Carpenter *et al.*, 1998). In a problem solving task, Chen and Siegler (2000) tested 18–35-month-old children for their ability to retrieve a toy using a tool, with and without modelling from an experimenter. Their results show that both younger and older children had significantly higher success rates after exposure to the experimenter's modelling.

A large body of work exists on social cognitive development starting approximately 9 months of age, including the emergence of joint attention, social referencing and intended communicative gestures (e.g. imperative and deictic pointing) (Bates, 1979; Carpenter *et al.*, 1998; Tomasello, 1995; Rochat, 2001; Striano and Rochat, 2000). In general, research shows that by their first birthday infants begin to construe others as intentional social partners with whom they can share attention and action on objects, in addition to sharing affects and emotions (Trevarthen and Hubley, 1978). The question is how this development impinges on social learning, in particular to what extent such development corresponds also to the emergence of an understanding of others as resource for instructional help.

In a rare study of joint play, Mosier and Rogoff (1994) observed mother–infant dyads and recorded examples of instrumental use of mothers by infants. They define instrumental use as instances where the infants used their mothers as a 'tool', such as taking the mother's hand to reach for a toy, or looking at a toy and the mother's hand but not at the mother's face. They report that instances of instrumental use increases significantly between 6 and 13 months.

At early ages, if infants use their mothers as a tool for action, it is without any apparent signs of intentional communication. For example, they might take the mother's hand and bringing it to a toy to perform an action, without looking at her (Mosier and Rogoff, 1994). Studies on conventional symbolic communication show that pointing to an object and the propensity to show an object to an adult with gaze alternation emerge around 9–10 months of age, becoming more frequent between 12 and 15 months of age (Bates *et al.*, 1975; Bates, 1979; Tomasello, 1995, 1999; Carpenter *et al.*, 1998; Bretherton *et al.*, 1981; Ross and Lollis, 1987; Bakeman and Adamson, 1986). These changes represent a shift from using the adult as a mere instrument to a partner in action (Phillips *et al.*, 1995). Note that these changes are confounded with major shifts in social-emotional development that are documented in the experimental literature on attachment (Ainsworth and Wittig, 1969). It is around the age of 8–9 months that infants typically begin to manifest separation and stranger anxiety when temporarily separated from their mother or when facing a new person in their environment (Spitz, 1965; Bowlby, 1969). Thus, the emergence of triadic exchanges and secondary intersubjectivity by the first birthday of the child cannot be dissociated from important development in affective, emotional and interpersonal development, including the growth of attachment (Trevarthen, 1998; Reddy *et al.*, 1997). By 9 months, infants do develop new abilities to communicate that allow them on one hand to maintain proximity with others (attachment), and on the other to engage in distal exploration of the physical environment afforded by the acquisition of new degrees of behavioural freedom as postural and locomotion abilities develop (Rochat, 2001).

From a social-cognitive perspective, Mosier and Rogoff's study documents infants' ability to communicate with their mother about an object, it does not provide information as to when infants begin to request for help and to learn from an adult's demonstration in solving a practical problem. In the present research, we ask at what point infants might begin to use others to solve a problem, when they begin to elicit help and instruction from an adult. In general, two questions drive the research: (1) when and how infants become aware of others as a resource for help and instruction, (2) when and how infants become sensitive to others' assistance and instruction as they face a problem they cannot solve on their own.

We presented 9–18-month-old infants with six different problems of increasing complexity, each problem being imbedded in the preceding one. Infants had online access to an adult modelling the solution when needed. We tracked developmental changes in the propensity to request help from the experimenter, and to use the adult's modelling of the solution to solve the various problems at hand. We considered the extent to which infants display communicative gestures to entice help from the adult. We recorded and analysed gestures such as pointing with and without alternation of gaze between object and person, the showing of objects to an adult, and open or close hand extensions toward a desired object. Considering that joint attention and social referencing emerge by 9 months of age and that by 18 months these skills are well established in their repertoire, we were interested in the question of how infants between 9 and 18 months would progressively incorporate such social gestures in a problem solving context as expression of emerging collaboration and the initiative to learn from more advanced others.

Each problem included several steps, starting with a basic means-end Piagetian task where an attractive toy was placed on a mat, and infants had to pull the mat toward them to retrieve the toy (Piaget, 1952; Willatts, 1984). The task was repeated, the object placed into various transparent boxes that were increasingly difficult to open, thus eventually enticing children to request help from the experimenter. The embedded nature of the task allowed for a dynamic problem solving context where infants had a chance to revisit a problem taking into account previous help from the experimenter.

METHOD

Participants

Thirty three infants aged between 9 and 18 months of age participated in this study. Three infants were eliminated because of fussiness or lack of cooperation. The final sample included 19 boys and 11 girls, divided in three age groups: nine 9–10 month olds (M = 39.8, S.D. = 3.2; 6 boys), 10 14–15-month-olds (M = 59.8, S.D. = 2.4; 7 boys), and 11 18–19-month-olds (M = 75.9, S.D. = 2.1; 6 boys). All infants were born full-term and healthy according to parental reports. Infants were recruited from a participant pool from the Atlanta area. Parents were contacted by phone, and offered to participate in the study. Eighty four per cent of infants were Caucasian, 16% were African American. All came from middle to upper middle class families.

Apparatus

A video camera mounted on a tripod (Panasonic Model AG-186) recorded each session providing an en face view of the infant and the experimenter. A white backdrop hanging in front of the infant and to the side prevented distraction and hid the camera. Infants were seated at a table onto which the experimenter presented the successive problems.

Procedure

The infant sat on the parent's lap facing a large table at chest height. The female experimenter kneeled to the right of the infant introducing the various objects on the table. Parents were instructed not to intervene during the experiment, just smiling and acknowledging their child when he or she turned toward them. Such turning around of the child toward the mother only happened in rare occasions. The experimenter was the only adult interacting with the child and the task was very compelling for all participants. The session started with a brief warm-up period during which the experimenter gave the infants a toy and let them play with it until they were comfortable with the setting. Following the warm-up session, infants were presented with six increasingly difficult means-ends task problems. In each problem, the goal was to retrieve a distal attractive toy either placed on a mat, or placed on a mat inside various transparent boxes, some with various locking devices. These problems are presented below, in the chronology of their presentation during test (see also Table 1). Before each problem the experimenter showed the target object (toy or sticker) to the child and tested his or her interest by letting her hold it. If the child demonstrated interest via reach attempt and/or vocalization, in addition to oriented gaze, toward the object/sticker, the problem started. If interest waned, a new object/sticker was presented.

Problem 1: A small, 3×1 cm plastic toy animal was placed out of direct reach of the infant (approximately 1 m away) on a mat spread over the table in front of the child. In order to retrieve the toy, infants had to grab the mat, pull it toward them and reach for the object once reachable (three-step action as in the simple means-ends Piagetian task, Piaget, 1952).

Problem 2: The toy was placed inside a square transparent plastic cube with an open top side ($6 \times 6 \times 6$ cm) sitting on a mat. Once infants grasped and pulled the mat toward them, they could retrieve the object by reaching for the cube and inserting their hand inside the open face of the cube (four-step action).

Problem 3: The open face of the transparent cube was over the toy. To retrieve the toy, the infant had to grasp the mat, pull the mat, touch the cube, lift it, and then reach for the toy (five-step action).

Problem 4: The toy was placed inside yet another transparent box. This box was a small ($5 \times 5 \times 5$ cm) plastic suitcase with a black handle on top and a black lock on the front that needed to be lifted up by the infant to open the hinged top and gain access to the toy. To retrieve the toy, the infant had to perform the five-step action of problem 3 plus touching the suitcase and opening it (seven-step action).

Table 1. Performance scores for Problems 1–6. One point was attributed for each action performed

Problem 1: score from 0 to 3	Problem 2: score from 0 to 4
Touch mat	Touch mat
Pull mat	Pull mat
Pickup toy	Touch cube
	Pickup toy
Problem 3: score from 0 to 5	Problem 4: score from 0 to 7
Touch mat	Touch mat
Pull mat	Pull mat
Touch cube	Touch cube
Lift cube	Lift cube
Pickup toy	Touch suitcase
	Open suitcase
	Pickup toy
Problem 5: score from 0 to 9	Problem 6: score from 0 to 11
Touch mat	Touch mat
Pull mat	Pull mat
Touch cube	Touch cube
Lift cube	Lift cube
Touch suitcase	Touch suitcase
Open suitcase	Open suitcase
Touch white box	Touch white box
Open white box	Open white box
Pickup toy	Touch small box
	Open small box
	Pickup sticker

Problem 5: Same as problem 4, but the toy (a sticker now) was put in yet another transparent box inside the suitcase. This box consisted in a white plastic box ($3 \times 3 \times 2$ cm) with a transparent cover that could be opened by pulling the cover's ledge. The box opened easily; minimal strength was required. With this new box, an additional two step action was required (total of nine-step action).

Problem 6: Same as problem 5, but the sticker toy was put yet in another small transparent box ($2 \times 2 \times 1$ cm) with a lid that was tightly snapped on top. To open the lid, the infant had to undo two tight snap-on parts at the edge of the box, a highly difficult and unlikely operation for all tested children. With this additional box, two steps were added to the whole retrieving operation now requiring 11 steps, from grasping and pulling the mat to opening all the successive boxes in order to retrieve the toy object.

In between the successive problems, the table was occluded to the infant by a white opaque foam screen while the experimenter prepared the boxes and placed them on the mat for the next problem. Approximately 15 s elapsed in between problems. Trials ended either when the toy was retrieved by the infant or 15 s after modelling from the experimenter.

Experimenter's modelling

If the infant did not act for 15 s or following a request for help, the experimenter provided modelling cues directing the infant's attention to the next appropriate action step. For example, in Problem 1, if an infant did not pull the mat after 15 s, the experimenter touched and lifted the mat up–down in front of the child. If the infant did not respond to this cue, the experimenter gave an additional modelling cue by lifting the mat and pulling it a few centimeters, thus demonstrating the means-ends causal link. At this juncture, if the infant still did not learn from this cue, the object toy was given to the child and no point added to the score in the coding. The next problem was then presented. This accounts for the fact that even with modelling, the child's score did not always reach 100%.

The same modelling procedure was applied for *each* step of all problems whenever any of the boxes were in the child's hands. If, for example, the child tried but could not open one the boxes, whether it followed a request for help or after a 15 s trying period, the experimenter gently grabbed the box and modelled its opening and closing. She then handled the box back to the child with its lid closed. For coding, in order to score a point after this modelling, the child had to open the box. If the child even after modelling did not do the gesture, then the experimenter opened the lid, left it open, and no point was coded for that particular gesture. Once the box was opened, if the child picked up the toy, 1 point was added for picking it up (see Table 1 for coding and point calculation). The total testing session typically lasted less than 15 min. At the end of the session, infants were given a sticker and a diploma as a token of appreciation.

Dependent measures

Videotapes were scored in relation to three kinds of variables: (1) success prior to experimenter's modelling; (2) sensitivity to experimenter's modelling; and (3) communicative gestures toward the experimenter.

(1) *Success prior to step modelling*: A rating scale was established to code infant's success in each step of each problem. Scored ranged from 0 to 11 and were calculated as follows: (a) the first step of each problem was coded on a three-point scale (1 point for touching the mat, 1 point for pulling the mat, and 1 point for touching the object); (b) from the first step, there were cumulative points corresponding to each additional action required by a particular problem, with a maximum of 11 points at Problem 6 (see Table 1 for a description of the problems and the point scale). For example, if an infant solved by herself the four steps of Problem 2 (i.e. with no model), she got a score of 4. If however she got through step 1 by herself (touched the mat), did step 2 only after the experimenter modelled the solution, then touched the cube and picked up the object by herself, her total score prior to step modelling was 3. For later comparison and statistical analyses, totals for each problem were converted in percentages relative to the maximum obtainable points in a particular problem task; (c) finally, success in opening the suitcase prior to step modelling was coded. The suitcase was presented three times in a row, as part of Problems 4–6. For each of these trials a three-point scale was used for coding with 1 point for touching the suitcase, 1 for lifting the lock, and 1 for lifting the cover.

(2) *Sensitivity to experimenter's modelling*: To assess infants' sensitivity to the Experimenter's modelling, we recorded how infants responded to the experimenter's modelling cues. We created a 'sensitivity' score based on the success observed at each step relative to the number of modelling cues received at this particular step. The sensitivity score only concerned instances where a modelling had occurred. For each step of each problem, we coded for successes that occurred only after the experimenter modelled the solution. A successful

modelling occurred when a child was able to repeat the gesture the experimenter just performed such as for example, pulling the mat or opening a latch. We calculated the ratio of success to modelling by dividing 0 (no success) or 1 (success) by the number of preceding modelling cues provided by the experimenter. In other words, the ratio varied between 0 (no success) to 1 (success following only one modelling by the experimenter). Ratio of a fraction of 1 consisted of a success following more than one modelling by the experimenter.

(3) *Communicative gestures*: Four different types of communicative gestures were recorded during the child's problem resolution attempts. These gestures are construed as part of various strategies to seek help from the adult. These gestures were reaching, pointing, object showing, and co-occurrence between gazing toward the experimenter and apparent requests presumably for help. Reaching consisted in arm extension toward the object, hand being open or closed without a body extension. Although not a conventional gesture of communication, the reaching gesture was interpreted as primitive pointing, prior to the ability to isolate the index finger. However, if an infant opened her hand wide and at the same time extended her body, we did not score this behaviour as a communicative gesture because in this case, the infant was geared towards an attempt to get the object without any reference to the experimenter. Pointing consisted in arm extension and a clearly extended index isolated from the other fingers. These two types of gestures could be expressed only in the first step of each problem when the object was out of reach. Episodes of pointing and reaching were pooled in later statistical analyses because of few instances of pointing.

In the last three problems, infants were presented with a succession of boxes to be opened. When they could not succeed on their own, we considered instances where infants showed these boxes to the experimenter by either holding a box toward the experimenter, or by placing it into her hands (object showing). These behaviours were construed as requests for help. Object showing were analysed separately from the other communicative gestures because they could occur only during the last three problems. However, these three problems varied in the number of objects infants could show the experimenter. In Problem 4, there was only one object to be shown (i.e. the suitcase); in Problem 5, two objects (i.e. the suitcase and the white box), and in problem 6, 3 objects (i.e. the suitcase, the white box, and the small box). Each of these objects could be shown repeatedly within a problem. For comparison across the three problems, we calculated the mean number of showing instances relative to the number of possible objects that could be shown to the experimenter (i.e. number of showing instances divided by the number of objects that could potentially be shown for each problem.

Finally, the mean percentage of co-occurrence of gazing and other communicative gestures toward the experimenter was calculated for each problem. For each instance of gazing at the experimenter, scorers noted whether there was simultaneously a request (pointing, reaching, or object showing) to the experimenter (number of requests divided by number of gazes per problem $\times 100$).

Reliability

Videotapes were coded by two blind and independent coders and reliabilities were computed on 25% of the data for performance scores across problems, number of requests (pointing, reaching, object showings), and co-occurrence between gazing and requests. Pearson coefficient was 0.99 for performance scores and Cohen's kappa was 0.86 for requests and 0.71 for co-occurrence.

RESULTS

Results are presented in two main sections corresponding to the objectives of the study. One objective of the study was to assess infants' ability to use an experimenter to solve a problem. To answer this question, we first report infants' success prior to step modelling, and then infants' sensitivity to the experimenter's modelling. Next we document infants' communicative gestures during the course of a problem solving task, and for this purpose we analysed infants' communicative gestures such as pointing, reaching, object showing and the co-occurrence of gestures with gazes.

(1a) *Success prior to step modelling*. Success prior to step modelling across the six problems was first analyzed. Nine-month-old infants solved on average 63.11% of the problems (S.D. = 6.64) prior to step modelling while 14 and 18-month-olds solved, respectively, 70.24% (S.D. = 5.39) and 67.24% (S.D. = 3.16). Success prior to step modelling was analysed in a 3 (age) $\times$ 6 (problem) ANOVA, and yielded a main effect of problem, $F(5, 110) = 2.27$, $p < 0.05$. Simple effects indicated a quadratic relationship, $F(1, 22) = 5.50$, $p < 0.05$ with higher scores in Problem 3. An age $\times$ problem interaction was also found, $F(10, 110) = 1.93$, $p < 0.05$. Planned contrasts showed that 18-month-olds had higher success rates than 9-month-olds on Problems 5 and 6, respectively, $t(17) = 2.32$, $p < 0.05$ and $t(17) = 3.19$, $p < 0.05$. Moreover, 18-month-old infants improved significantly their success rates between problems 1 and 6, $t(10) = 3.83$, $p < 0.05$. By contrast 9-month-olds showed a decrease in success rate between Problems 1 and 6, $t(7) = 2.43$, $p < 0.05$ (Figure 1). No difference was observed in 14-month-olds. No significant age difference was found.

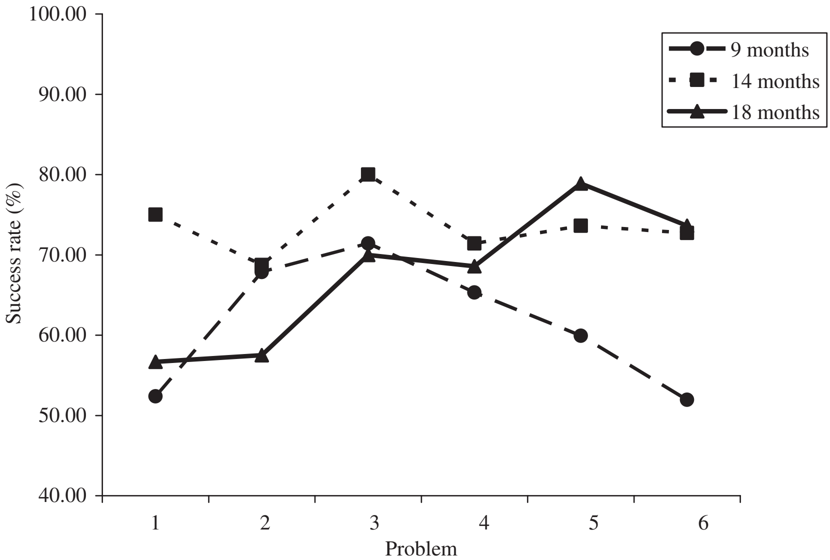

Figure 1. Per cent success in Problems 1–6 with all steps included prior to step modelling.

Success on the first step only of each problem was then analysed. Table 2 displays the mean score for each problem across groups before step modelling. A 3 (age) $\times 6$ (problem) ANOVA on the means yielded an age $\times$ problem interaction, $F(10, 110) = 2.36$, $p < 0.01$.[1] *T*-tests comparing 18-month-olds with 9-month-old infants showed that the older group had significantly lower success rates than the youngest group on Problem 2, $t(15) = 2.66$, $p < 0.05$, and Problem 4, $t(17) = 3.1$, $p < 0.01$. The 18-month-olds were also less successful than 14-month-olds on Problem 1, $t(18) = 2.38$, $p < 0.03$. Eighteen-month-olds did, however, increase significantly their success rate in the last problem compared to the first one, $t(10) = 2.4$, $p < 0.05$ suggesting that they became more proficient over testing time. Nine-month-olds and 14-month-olds did not show such significant change.

Interestingly, the level of success in coordinating means and ends (Step 1: pulling the mat and grasping the object) of the 18-month-olds, as compared to the two younger groups, remained very low throughout the session. When the gesture of pulling the mat alone was analysed, (as opposed to the three-point scoring system), no 18-month-olds performed that gesture on Problems 1 and 2, and only 36% did in the last problem whereas for the other two younger age groups on average 50% of infants did pull the mat. Eighteen-month-old infants tended to try other strategies to bring the object within their reach without having to pull on the mat, such as stretching (all 18-month-olds tried this strategy repeatedly), and/or climbing on the table (6 out of 11). By contrast stretching and climbing were rarely observed in 9-month-olds (two infants stretching once each and one climbing), and 14-month-olds (two infants climbing once each, two infants stretching repeatedly).

Because of the low performance in pulling the cloth in 18-month-old infants, Problems 1 and 2 as well as the simple means-end component of each subsequent problem (touch and pull the mat) were excluded from further analyses. A 3 (age group: 9, 14, 18) $\times$ 4 (problem: 3, 4, 5, 6) ANOVA on the percentage of steps completed with no modelling yielded a main effect of problem, $F(3, 78) = 21.94$, $p < 0.0001$. Paired sample *t*-tests indicated that success on Problem 3 was lower than on the other problems (all $ps < 0.05$).[2] Age was also a significant factor, $F(1, 26) = 10.44$, $p < 0.0001$. Independent *t*-tests revealed that across problems 9-month-olds performed significantly less well than 14-month-olds, $t(16) = 3.01$, $p < 0.01$, and 18-month-olds, $t(17) = 4.48$, $p < 0.01$ (see Figure 2).

In Problems 4–6, infants were presented with a suitcase which could be opened by lifting the lock and then the cover. To obtain a perfect score infants had to touch the box, lift the lock, and open the cover (maximum of 3 points). A 3

Table 2. Mean scores and standard deviations for 9, 14, and 18-month-old infants prior to experimenter's modelling during first step of each problem (means-end mat test, maximum score = 3)

	9 months	14 months	18 months
Problem 1	1.75 (1.09)	2.11 (0.93)	1.53 (0.67)
Problem 2	2.00 (0.82)	1.67 (0.71)	1.20 (0.42)
Problem 3	2.38 (0.74)	2.00 (0.94)	1.73 (0.79)
Problem 4	2.5 (0.76)	1.80 (0.92)	1.36 (0.81)
Problem 5	2.25 (0.89)	1.80 (0.92)	1.73 (0.90)
Problem 6	1.75 (1.16)	2.10 (0.99)	2.00 (0.89)
Total	2.10 (0.93)	1.91 (0.90)	1.87 (0.70)

(age) $\times$ 3 (trial) ANOVA on the average number of points earned during the trials before modelling yielded a main effect of trial, $F(2, 52) = 3.73$, $p < 0.03$. Contrasts showed that infants' performance was significantly lower the first time the box was presented ($M = 1.59$, S.D. $= 0.81$) compared to the second time ($M = 2.04$, S.D. $= 0.91$), $t(28) = 2.64$, $p < 0.01$ but only marginally significant compared to the third time ($M = 2.01$, S.D. $= 0.94$). Moreover, planned contrasts showed that in the second trial, 18-month-olds had significantly higher rates of success than 9-month-olds, $t(17) = 3.54$, $p < 0.01$. They were also the only group to show a significant increase in success between the first and second trials (from 1.64 to 2.55), $t(10) = 3.19$, $p < 0.01$.

(1b) *Sensitivity to the experimenter's modelling*: In order to assess infants' sensitivity to the experimenter's modelling cues, we computed a sensitivity score based on the ratio of success to modelling for each step. Figure 3 displays the

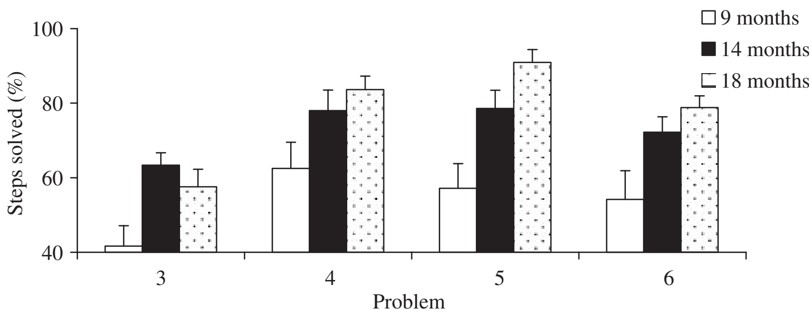

Figure 2. Per cent success in Problems 3–6 across ages before step modelling (cloth-task removed).

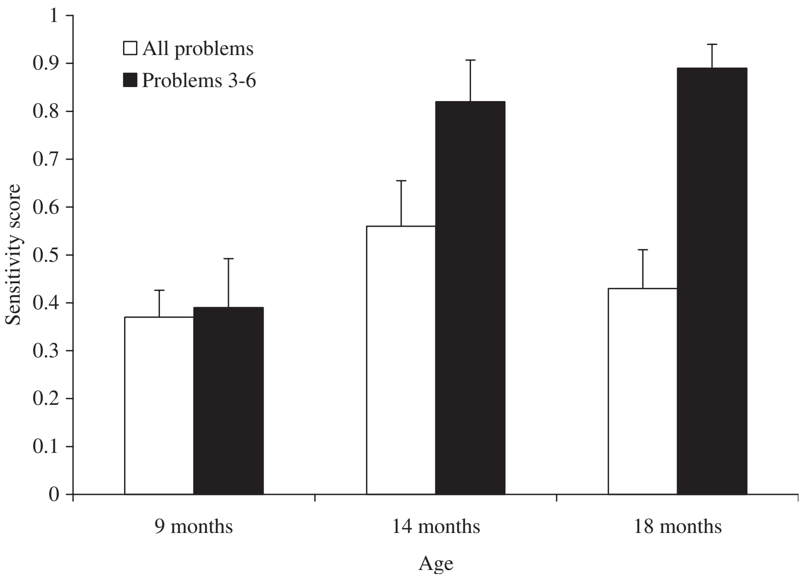

Figure 3. Sensitivity score as a function of age for all problems and all steps included (Problems 1–6) and with cloth-task removed (Problems 3–6).

sensitivity score for each problem with and without the first step included. Because not every subject received a model in each problem, we computed an average proportion pooling together the six problems. A 3 (age) univariate ANOVA on the proportion of success after a model with all problems and all steps included yielded no significant age difference. We then eliminated Problems 1 and 2 and the first two steps of each problem because of the low success rate of 18-month-old infants on that step. A 3 (age) univariate ANOVA on the proportion of successes after a model for Problems 3–6 yielded a main effect of age, $F(1, 29) = 10.73$, $p < 0.01$. Independent t-tests showed that 9-month-olds responded successfully to a model in only 40% (sensitivity score $\times 100$) of the cases whereas the 14 and 18-month-olds did so in 82%, $t(16) = 3.16$, $p < 0.01$ and 90% of the time, $t(17)=4.77$, $p < 0.01$.

For the suitcase trials in Problems 4–6, 9-month-old infants were sensitive to the experimenter's modelling 63% of the time (sensitivity score $\times 100$) whereas 14- and 18-month-olds were sensitive 93% and 91%, respectively. Table 3 shows a qualitative analysis of the percentage of infants who solve the three trials independently and the percentage of infants who received a model and were subsequently able to solve the task.[3] In general although the three age groups had a comparable rate of success in the first trial, the older group was more likely to succeed without any modelling from the experimenter in the subsequent trials. Moreover, whenever a model was offered, 18- and 14-month-old infants were more likely to benefit from the model with enhanced success rate compared to the youngest age group. Finally, 9-month-olds showed no improvement over trials whereas both 14- and 18-month-olds benefited from the repeated exposure to the task (see Table 3).

(2) *Communicative gestures*: The next goal of the study was to observe infants' social strategies while attempting to solve the problems, and in particular communicative gestures infants were inclined to make during problem resolution that we construe as possibly corresponding to explicit requests for help.

Pointing and reaching were observed in the first steps of the problems when the toy/box was out of reach on the mat. As mentioned earlier 9-month-old infants tended to be successful on the first steps of each problem and possibly as a result, 9-month-old infants had fewer pointing and reaching since presumably they would correspond to help request on the part of the child ($M = 0.21$, S.D. $= 0.19$) compared to the other two groups (14 months: $M = 1.69$, S.D. $= 0.53$; 18 months: $M = 1.82$, S.D. $= 0.62$). A 3 (age) $\times$ 6 (problem) ANOVA on frequency of pointing

Table 3. Percentage of 9, 14, and 18 month-old-infants able to open independently the suitcase, percentage of infants who solved the problem after modelling for trials 1, 2, and 3, and per cent gain across trials (number of infants in parentheses)

	% infants	Trial 1	Trial 2	Trial 3	Trials 1–2	Trials 1–3
9 months	Able to solve independently	37.5 (3)	12.5 (3)	37.5 (3)	−25%	0%
	Solve problem after modelling	40 (2)	71 (5)	60 (3)		
14 months	Able to solve independently	30 (3)	62.5 (7)	50 (5)	+32.5%	+20%
	Solving step after modelling	100 (7)	100 (3)	100 (5)		
18 months	Able to solve independently	36 (4)	91 (10)	73 (8)	+55%	+37%
	Solving step after modelling	86 (6)	100 (1)	100 (3)		

and reaching yielded an age difference, $F(1, 23) = 10.4$, $p < 0.01$ (see Table 4). Both 14- and 18-months-old infants demonstrated significantly more of such behaviours than 9-month-olds, ps < 0.01. The frequency of these behaviours also varied significantly across problems, $F(5, 115) = 2.94$, $p < 0.05$. A trend analysis showed that the frequency decreased in a linear fashion between first and last problem, $F(1, 23) = 9.63$, $p < 0.01$, suggesting that infants became proficient at solving the early steps of the problems after repeated exposure, without help solicitation.

Object showing to the experimenter: In Problems 4–6, infants had to open several boxes small enough to be lifted and possibly shown to the experimenter for help for opening them. Table 4 shows the mean number of object showings during Problems 4–6 and also during the three suitcase trials.[4] A 3 (age) $\times$ 3 (problem) ANOVA on the mean number of object showing per problem yielded a main effect of problem, $F(2, 54) = 5.85$, $p < 0.01$, and pairwise comparisons indicated that there were more showing instances in Problem 6 compared to problem 4, $t(29) = 4.02$, $p < 0.01$ (see Table 4). The same significant result was found when comparing Problem 6 to the average score of Problems 4 and 5, $t(29) = 3.81$, $p < 0.01$. No age effect was found.

Co-occurrence of gazing and requests: We examined the co-occurrence of gazing at the experimenter and other communicative gestures (pointing, reaching, and object showing) across problems. Such co-occurrence could index more specifically attempts by the child to solicit help from the adult A 3 (age) $\times$ 6 (problem) ANOVA on percentage of co-occurrences yielded a significant main effect of problem, $F(5, 110) = 9.6$, $p < 0.01$. Infants tended to display more co-occurrences in the last three problems than the first 3, $t(28) = 4.47$, $p < 0.01$. This result is consistent with the fact that the last three problems were more difficult and presumably required more input from the experimenter. The ANOVA also yielded a significant main effect of age $F(1, 22) = 5.52$, $p < 0.01$. Older infants (14- and 18-month-olds) tend to have significantly more co-occurrences than 9-month-olds, respectively, $t(9) = 3.68$, $p < 0.005$ and $t(10) = 2.61$, $p < 0.05$. Nine-month-old infants displayed fewer instances of co-occurrences at all stages of the study ($M = 3.92\%$, S.D. $= 7.47$) compared to either the 14 month ($M = 26.64\%$, S.D. $= 14.33$) or the 18 month olds ($M = 37.87\%$, S.D. $= 28.61$).

Table 4. Mean number of pointing and reaching requests, and object presentations, as a function of age, problem, and suitcase trials. Standard deviations are in parentheses

	9 months	14 months	18 months
Pointing and reaching			
Problem 1	0.37 (0.74)	2.2 (2.05)	2 (1.49)
Problem 2	0.25 (0.46)	2.12 (1.64)	2.7 (2.75)
Problem 3	0.5 (0.76)	1.25 (1.49)	1.7 (1.16)
Problem 4	0.12 (0.35)	2.12 (1.56)	2.2 (1.4)
Problem 5	0	1.25 (1.39)	1.3 (1.16)
Problem 6	0	1.12 (1.13)	1 (0.82)
Object presentation			
Problem 4	0.37 (1.06)	0.70 (48)	0.64 (0.81)
Problem 5	0.25 (0.46)	1.3 (1.06)	0.36 (0.67)
Problem 6	1.44 (2.18)	2.7 (1.64)	2.36 (1.80)
Suitcase trial 1	0.37 (1.06)	0.70 (48)	0.64 (0.81)
Suitcase trial 2	0.25 (0.46)	0.30 (0.48)	0.09 (0.30)
Suitcase trial 3	0.12 (0.35)	0.60 (0.69)	0.27 (0.47)

When co-occurrences were examined within each age group, 9-month-olds showed no significant change between the first three problems and the last three problems whereas the other two groups the frequency of co-occurrences increased significantly in the last three problems, $t(10) = 2.61$, $p < 0.05$ for 18-month-olds and $t(9) = 3.68$, $p < 0.01$ for 14-month-olds.

DISCUSSION

There were two main aims in this research: (1) to document infants' developing ability to solve physical problems in the presence of an adult experimenter, and assess their developing sensitivity to the adult experimenter's modelling of the problem's solution, and (2) to explore infants' developing propensity to make communicative gestures toward the experimenter in the course of problem solving, possibly in an attempt to seek help and gain from social cues. Infants were presented with a series of embedded problems of increasing complexity and were asked at first to solve these problems by themselves. If they failed to solve the problem alone or indicated some behavioural signs of request for help, the experimenter modelled the solution, then let the child resumes his or her attempt at solving the problem alone.

Overall, and not surprisingly, 18-month-olds improved their success rate over trials whereas 9-month-olds showed a decrease in performance as problems became more complex. The success rate at solving the most complex problems (3–6) was significantly higher for 14- and 18-month-olds as compared to 9-month-olds. However, unexpectedly, 14- and 18-month-olds in particular, had a significantly lower success rate compared to 9-month-olds regarding the first problem (means-end mat pulling of the object-toy). It appears that some of the older infants were inclined to use leaning and locomotion, a newly acquired skill, for direct access toward the object-toy, many of them climbing the table with arms extended, clearly overlooking the mat as a possible means to an end. It appears that for these children, the use of newly acquired effectivities of the body was a priority, overlooking the more economical means-end solution that is well documented to be a landmark development already by 9 months of age (Piaget, 1952; Willatts, 1984). This overlooking is obviously not due to a lack of means-end ability, but rather to a different mindset. Some of the older infants demonstrated that the problem of bringing the object close to them was more than a physical problem to be resolved. The problem also became social rather than purely physical, the infant pointing, sometime whining while looking up toward the experimenter in an attempt at mobilizing her to gather help and attention. This latter behaviour suggests that by 18 months, infants become socially preoccupied to a point that their need is not only to solve problems related to physical objects, but also and probably more importantly, to maintain social proximity and engagement.

Our interpretation is that by 14–18 months, infants manifest different motives in solving the physical problems offered to them as compared to 9-month-olds. First they are driven to use newly acquired motor skills and the novel degrees of freedom offered by locomotion and new controls over whole body engagements. Second, and maybe more important, the physical task becomes an eminently social one, the infant now trying, not only to solve the problem *per se*, but also and maybe primarily, to maintain the adult's attention and engagement over what they are trying to achieve. By 18 months, it becomes difficult for the infant to ignore the presence and attention of the adult as they engage with physical objects.

Our results corroborate the notion that by the middle of the second year, toddlers become increasingly *co-aware* of what they do or try to achieve with objects (Rochat, 2001, 2003). Analyses on infants' sensitivity to the experimenter's cues showed that in general, 14- and 18-month olds used the experimenter's help more efficiently than younger infants. In fact, in most cases, the two older age groups were able to pick up on the experimenter's modelling of the solution, and succeed in the task. Results with the suitcase confirmed that older infants benefited from the modelling they received. Although all groups required the same amount of guidance in the first trial, 9-month-olds were not able to use efficiently and consistently the modelling within and across trials. In contrast, by the third trial, only a few 18-month-old infants required modelling. Moreover, following a model 18- and 14-month-old infants showed increased success compared to the youngest age group. This suggests that the older age groups became not only sensitive to the experimenter's actions but also resourceful in using her as a model leading to resolving the problem. Note however, that it is possible that younger infants may have been sensitive to the experimenter's cues without demonstrating it. The exact mechanisms underlying such emergent social learning remain to be specified, whether observational learning, emulation, imitation, or guided participation (Bandura, 1986; Tomasello *et al.*, 1993; Meltzoff, 1996; Rogoff, 2003; Odden and Rochat, 2004). This study does not allow for a clear separation between these potential mechanisms. Another process that may have contributed to the age effect is that older infants had more experience with the various tasks and may thus have been more ready to incorporate modelling from the experimenter. Even though older infants frequently requested for help, their preparedness to the task probably contributed to them picking up modelling cues from the experimenter. In addition, note that older infants are likely to have developed greater capacities for processing such modelling cues.

As for the analysis of communicative gestures, in comparison to 14- and 18-month-olds, 9-month-olds demonstrated fewer presumed requests via pointing or reaching. In contrast to the older groups, 9-month-olds were more successful in solving the first step and this may explain why they did not show many requests for help at this level of the task. However, when they encountered difficulties at later steps, they made few requests. In contrast to 9-month-olds, 14- and 18-month-olds showed more sensitivity to the social context as resource for help and instruction. They made more contact with the experimenter, sharing attention by either pointing at or reaching for the desired object. Overall, they were also significantly more inclined to ask for help. When problems became more complex, requiring more steps to be solved, infants on the whole increased their propensity to show objects to the experimenter presumably as a form of request for help. This observation suggests that infants have some understanding, at least some implicit understanding, that the experimenter can be a source of help. Such understanding was visible at all ages. Note that in the last problem, when infants received modelling to open the last box, they generally tried to grab the box from the experimenter's hand as soon as they had witnessed the solution to the problem. This eagerness seems to support the idea that infants viewed the experimenter as a 'helping hand' and a teacher, rather than simply a play partner, and object showings of the box were not merely an invitation to play.

It appears that already by 9 months, infants tended to display increasing visual monitoring of the experimenter as the problems got more complicated. However, we observed a clear developmental trend in 14- and 18-month-olds regarding the way they related to the experimenter. When manifesting presumed help requests, older infants showed an increased tendency to accompany their requests with a simultaneous visual monitoring of the experimenter. In 9-month-olds, gesturing and gazing toward the experimenter were typically separated over time. Furthermore, 14- and 18-month-olds engaged in significantly more bouts of joint attention, particularly when struggling to find the right solution at a difficult juncture of the problem resolution. In contrast to the younger infants, they tended to alternate gazes toward the experimenter and to the toy's container(s), monitoring her attention to their effort at finding the solution.

In general, we interpret these observations, and in particular the developmental phenomenon reported here, as the expression of an emerging understanding of others as potential source of information, help, and teaching by the beginning of the second year. This understanding is not yet explicit and can be construed as signs of early implicit folk cognition or theories of mind. Requesting for help and attunement to others as model for solving practical (here, sensorimotor) problems implies, we propose, some important implicit understanding about people by the infant. We can assume that this understanding includes that (1) the other is willing to help; (2) she has more knowledge regarding the problematic situation at hand; (3) she understands the encountered difficulty at solving the problem. These three putative implications would underlie the help requests that become significantly more frequent by 14 and 18 months of age. Note however that precursor signs of such requests are evident already by 9 months and are reported even prior to 9 months in some instances, prior to the transitions leading to secondary intersubjectivity (Hubley and Trevarthen, 1979). Such precursor signs suggest that young infants early on, have already some intersubjective capacities that are foundational to later developmental transitions toward a collaborative and instructional stance (Reddy, 2003).

We conclude that by at least the middle of the second year infants begin to manifest implicit theories of mind that are the precursors of later, well documented explicit understanding of people's beliefs and other mental states typically emerging by 4–5 years of age (Wimmer and Perner, 1983; Callaghan and Rochat, 2003). Much more research is needed to specify the nature of early implicit theories of mind, what developmental mechanisms underlie them, as well as what characterizes the transition from the kind of implicit understanding of others documented here, to later explicit understanding of people as invaluable resource and potential agents of novel information. In particular, these transitions could be captured in more detail by observing infants within a narrow age range.

Documenting this transition is a crucial task because the developmental progression in help seeking behaviour could be a marker of emerging behavioural propensities that are unique to humans compared to other animal species. Namely, it might capture the emergence of the ability to learn via teaching and instruction from others (see Tomasello *et al.*, 1993; Tomasello, 1999). The ability to instruct and learn from others is sometimes thought of as an important aspect differentiating humans from other mammalian and avian species (Tomasello and Call, 1997; Tomasello, 1999).

For the future, these observations should be complemented by research on what determines infants to learn from others. Taking into consideration variations in temperament would be important, as well as infants' attachment styles. Such factors might mediate the engagement and motivation of a child during an interactive task with a new adult. Using a learning experimental design with longitudinal data would also be valuable (see for example Callaghan and Rankin, 2002). Finally, the question of the extent to which young children are already selective to others' characteristics remains unanswered. For example, we do not know how a more familiar experimenter might have affected infants' engagement and general motivation. Such research could provide important information as to what makes the young child a social learner and what makes people surrounding the child more or less effective teachers. In many ways, this kind of studies would help elucidate the origins and basic psychological underpinnings of teaching.

ACKNOWLEDGEMENTS

The authors wish to thank Sarah Green and Jonathan Hart for their help in data scoring.

Notes

1. One 9-month-old and one 14-month-old had missing data for one problem each and had to be excluded from this ANOVA. However, they were used in all the *t*-tests except for the missing data in one problem.
2. Bonferroni correction was applied for all contrasts.
3. Statistical analyses could not be done because of low *n*.
4. Note that in this case Problem 4 is also suitcase trial 1 since only one box was presented to infants.

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