

# A Gray Seal's (*Halichoerus grypus*) Responses to Experimenter-Given Pointing and Directional Cues

Ari D. Shapiro, Vincent M. Janik, and Peter J. B. Slater  
University of St Andrews

A gray seal (*Halichoerus grypus*) was trained to touch a target on its left or right by responding to pointing signals. The authors then tested whether the seal would be able to generalize spontaneously to altered signals. It responded correctly to center pointing and head turning, center upper body turning, and off-center pointing but not to head turning and eye movements alone. The seal also responded correctly to brief ipsilateral and contralateral points from center and lateral positions. Pointing gestures did not cause the seal to select an object placed centrally behind it. Like many animals in similar studies, this gray seal probably did not understand the referential character of these gestures but rather used signal generalization and experience from initial operant conditioning to solve these tasks.

Shifts in body alignment, pointing gesture orientation, head alignment, and gazing direction (eyes alone) can alter the focus of attention in human social interactions. Most conspicuously, manual pointing, the making of deictic gestures, can transfer an individual's attention to an object, location, or event by locating it in space with the gesturing arm (De Waal, 2001). The pointing gesture is a referential signal that can be used universally to refer to any physical entity in the environment. This makes the real world context crucial for the appropriate usage and comprehension of pointing (S. R. Anderson & Keenan, 1985) and requires this context to be understood by both the pointer and the observer for communication to occur. Motivation and the internal state of the signaler are irrelevant in comprehending the pointing gesture because it directs attention to a feature of the external environment.

An important distinction has been made between gaze following, the capacity of an individual merely to track the gaze of another individual to an arbitrary point in space, and joint visual attention, in which this gaze is tracked to the precise object on which the attention of this second individual is fixated (Emery, Lorincz, Perrett, Oram, & Baker, 1997). The implications of an ability to adjust one's attention according to these cues have been extended to visual perspective taking (Povinelli, Nelson, & Boy-

sen, 1990), self-awareness (Povinelli & deBlois, 1992; Povinelli et al., 1990), and theory of mind (Povinelli, Bierschwale, & Cech, 1999). Of course, appropriate responses to pointing gestures and gazing cues do not necessitate self-awareness or theory of mind, but the complexity and flexibility of the usage and representation of these signals would be greatly enhanced if these phenomena were present.

Pointing as a social and communicative gesture emerges early in human development. Half of the infants in one study were pointing by roughly 12.5 months of age (Leung & Rheingold, 1981). The ability of infants to use pointing cues to guide their visual attention is present before they begin to point themselves but improves with age and with their own use of the gesture. By age 2, toddlers were capable of spontaneously using the direction provided by a pointing cue to find hidden objects (Povinelli, Reaux, Bierschwale, Allain, & Simon, 1997). Children between 2.5 and 3.0 years of age respond correctly to pointing at levels above chance (Tomasello, Call, & Gluckman, 1997). Despite their success in these studies, 3-year-old children were surprisingly unable to articulate why they selected the cup indicated by a pointing gesture (Povinelli & deBlois, 1992). The majority of 4-year-old children, however, provided answers revealing they understood that their knowledge of the correct cup arose from observing the direction of the pointing gesture. A developmental decoupling seems to exist in humans between the appearance of appropriate responses to pointing behavior and the corresponding comprehension of how this visual information produces knowledge.

As infants grew older, their ability to use the head orientation of an experimenter to shift their attention in the same direction matured (Scaife & Bruner, 1975), but difficulties in localizing objects outside their visual fields lingered until between 12 and 18 months of age (Butterworth & Jarrett, 1991). Using changes in head orientation to locate targets was most accurate when the correct choice lay first along an infant's visual scanning path, with 18-month-olds searching behind them once their visual field had been cleared of all other targets (Butterworth & Jarrett, 1991). Three-year-old children correctly selected a target object when an experimenter's gaze was directed at the object but not above it (Povinelli et al., 1999).

---

Ari D. Shapiro, Vincent M. Janik, and Peter J. B. Slater, School of Biology, University of St Andrews, St Andrews, Fife, United Kingdom.

Ari D. Shapiro is now at the Department of Biology, Massachusetts Institute of Technology.

Ari D. Shapiro was supported by a United States–United Kingdom Fulbright Graduate Student Scholarship, and Vincent M. Janik by a Royal Society University Research Fellowship. The facility was managed and the work was conducted according to regulations provided by the Home Office Animals (Scientific Procedures) Act 1986. The Home Office Project License 60/2589 permitted the facility to capture and care for the animal. We thank Jean-Yves Georges, Kate Grelhier, Ailsa Hall, Simon Moss, Ruth Sharples, and Carol Sparling for assisting with data recording.

Correspondence concerning this article should be addressed to Vincent M. Janik, Gatty Marine Lab, School of Biology, University of St Andrews, St Andrews, Fife KY16 8LB, United Kingdom. E-mail: vj@st-andrews.ac.uk

These extensive data on humans raise the question of whether nonhuman animals possess an analogous ability to develop an understanding of deictic gestures. Correct responses to human pointing commands have been observed in domesticated dogs (*Canis familiaris*: Hare & Tomasello, 1999; McKinley & Sambrook, 2000; Miklósi, Polgárdi, Topál, & Csányi, 1998; Soproni, Miklósi, Topál, & Csányi, 2001), capuchin monkeys (*Cebus apella*: J. R. Anderson, Sallaberry, & Barbier, 1995), orangutans (*Pongo pygmaeus*: Call & Tomasello, 1994; Itakura & Tanaka, 1998), gorillas (*Gorilla gorilla*: Peignot & Anderson, 1999), chimpanzees (*Pan troglodytes*: Itakura & Tanaka, 1998), bottlenose dolphins (*Tursiops truncatus*: Herman et al., 1999; Tschudin, Call, Dunbar, Harris, & van der Elst, 2001), and a horse (*Equus caballus*: McKinley & Sambrook, 2000). Because the ability to engage in and respond to pointing and gaze following offers a window on cognitive complexity and mental representation, the performance of numerous taxa in these kinds of studies might refine interpretations of what success and failure truly signify.

The success of the animals in these studies has encouraged a range of explanations from those firmly grounded in mentalistic interpretations to others assuming minimal higher level cognitive functioning. Gaze following and monitoring contain stronger evidence for theory of mind because they may implicate an understanding of the visual perspective of others and of how visual access to the environment imports this information into the brain. Visual co-orientation, turning the head and gazing in the parallel direction of another individual, has been demonstrated in numerous primate species by examining their response when they observe humans alter their gaze. Positive results have been obtained with chimpanzees (Call, Hare, & Tomasello, 1998; Povinelli & Eddy, 1997) and stump-tailed macaques (*Macaca arctoides*) but not black lemurs (*Eulemur macaco*; J. R. Anderson & Mitchell, 1999). In the slightly unnatural scenario in which the attention of a subject was attracted by waving an orange above its head from a tower, five primate species (chimpanzees, sooty mangabeys [*Cercocebus atys torquatus*], rhesus macaques [*Macaca mulatta*], stump-tailed macaques, and pigtail macaques [*Macaca nemestrina*]) followed this subject's gaze upward to investigate the source of the distraction (Tomasello, Call, & Hare, 1998). Finally, rhesus macaques examined an object receiving the visual attention of a videotaped conspecific for significantly more time than a symmetrically placed distracting object (Emery et al., 1997).

Many studies on animals suggest that the understanding of directional cues indicates an understanding of the referential nature of such gestures. However, human signals can also be used to train animals in a simple conditioning procedure. Thus, an interpretation of pointing studies requires careful evaluation of other possible mechanisms that may be at work. For example, reactions to varying distances between the experimenter and the target object or to novel hand signals (e.g., contralateral pointing) provide information on how an animal generalizes among various cues but do not suggest an understanding of reference.

In this study, we tested the ability of a wild caught, previously untrained, young gray seal (*Halichoerus grypus*) to respond to human pointing and directional cues. The central aim was to determine whether generalization from operant conditioning might account for the performance observed in pointing tasks. If so, we would expect that the subject, once trained in a general two-choice pointing task, might generalize its response to other similar signals

but would not respond correctly if pointing was used to refer to novel objects in its environment. The results we present call into question whether speculation on the basis of previous similar studies about the presence of mental complexity and theory of mind has been justified. Indeed, introducing other species to the experiments presented here might yield considerably different, more cautious interpretations of the cognitive mechanisms responsible for their performance when exposed to experimenter-given directional cues.

## Experiment 1: Pointing With Directional, Postural Gestures

After the seal had been trained to respond correctly to full-arm pointing, this experiment addressed the salience of different pointing cues to direct it to an appropriate target object.

### Method

*Subject and background.* Nora, a female gray seal (*Halichoerus grypus*) between 4 and 6 months of age, was used for all experiments in this study. After weaning at around 18 days of age, gray seals are solitary or associate with other seals of similar age (Bonner, 1972). Social learning seems to be of no importance to the acquisition of foraging skills because adults leave the breeding colonies much earlier than their young so that young gray seals are not exposed to foraging adults before they have to find food for themselves. Born in the wild on the Isle of May in the Firth of Forth, Nora was caught at around 1 month of age and housed at the captive research facility of the University of St Andrews, St Andrews, Fife, Scotland. She shared the facility with a male and female of the same age, 1 subadult female, and 1 adult female. All animals were fed herring with multivitamin and iron supplements daily.

Before these experiments commenced, Nora had been trained to station on a white, wooden square attached to a black polyvinyl chloride (PVC) pole to facilitate moving her within the facility. This was achieved initially by softly hitting the floor twice with the object to get her attention, touching her nose with the square, producing a bridge sound (with a dog clicker), and finally giving a food reward. After fewer than 10 trials, Nora would touch the wooden square whenever the object was presented to her. She was also trained to respond correctly (nearly 100% accuracy) to pointing gestures issued by the right hand of an experimenter to a target white square on the left and right (considered here and for the remainder of this article from the perspective of the experimenter). For this purpose, we installed two white objects in her enclosure about 2 m apart on the same wall. Initially, we used a similar black PVC pole to touch one of the objects, so that the overall visual impression to the seal was similar to what she had experienced before (i.e., a white object at the end of a black PVC pole). Again, after fewer than 10 trials, Nora touched the object indicated by the black pole. In the next step, we gradually increased the distance between the end of the black pole and the object in her enclosure. After fewer than 20 trials, she started touching the object rather than the end of the pole. The experimenter held the pole in his right hand during all trials. In the final step, the experimenter replaced the pole by using either his left or right arm to point at the required object. Note that this was purely a conditioning procedure and did not require understanding of pointing as a referential gesture. No other training was performed on Nora, and she had no other contact or previous experience with humans outside of these training trials. The time between her first training and the experiment described below was 3 months.

*Facility.* The open-air captive research facility contained a large rectangular pool (42.0 m × 6.0 m × 2.5 m), used mostly for respirometry, diving, and feeding experiments, and two smaller circular pools (with 3 and 5 m diameters and 2 m depths) for holding animals between experimental

procedures. All pools provided access to dry areas for the animals to haul out.

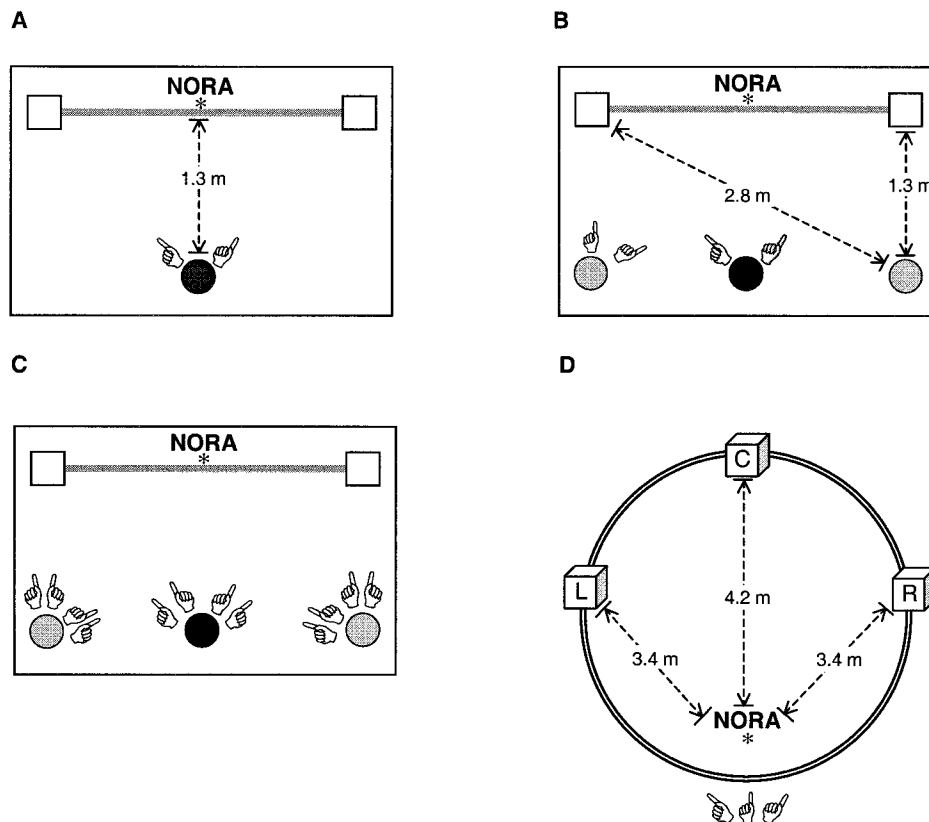
**Experimental setup and target objects.** All sessions were videotaped to monitor the outcome of each trial and any unique behavioral observations. A 2.5 m metal gate at one end of a rectangular dry area prevented Nora from approaching the experimenter and food bucket. A plastic Tupperware container was suspended 30 cm off the ground in the center of this gate. It served as Nora's starting position and as a reference point for the experimenter to position himself centrally in each trial. Two white, wooden squares (with a side length of 15 cm) were secured to either end of the gate at ground level. The one connected to the PVC pipe was laid in place, and the other was cable tied to one of the metal bars. The squares were swapped after half of the sessions to control for any reaction differences arising from discrepancies in stimulus quality. The stool on which the fish bucket sat in Experiment 1 was moved similarly to balance any unintentional spatial asymmetries.

**Procedure.** Six sessions of 30 trials each were conducted over 6 days (April 10–18, 2002). The experimenter wore an orange raincoat and green glove on the right hand while standing 1.3 m away from the center of the gate. Each trial began by rapidly raising the (ungloved) left hand, stating the subject's name, and slowly lowering the hand to the side. The seal then stationed on the Tupperware container until a subsequent signal was administered.

Five directional commands to the left or right were possible: pointing (P), pointing and head turning (P+H), upper body turning (UB), head turning (H), and gazing (E). P trials required the experimenter to lower his head to his chest and use his right, gloved arm to point to the appropriate square with his hand and index finger extended. The P+H trials were identical except the head and eyes were directed toward the focus object as well. The body from the waist up was rotated to the left or right during UB trials. The head alone turned left or right with eyes focused on the appropriate target object in H trials. During E trials, only the eyes were moved left or right to look at one of the squares (see Figure 1a).

A probe trial technique (Soproni et al., 2001) was used in which every series of five trials consisted of three P trials and two other directional cues. The order was randomly assigned but with half of the correct responses in the session to the left and half to the right. Each novel directional command was tested three times during each session, but no attempt was made to balance indicating left and right within command type. Because the gestures of the experimenter uniquely revealed in a random order the appropriate square to select, Nora could not have been informed by other cues (e.g., odor from a laterally placed reward or habituation to a pattern in the pointing sequence).

Once the command was issued, it was maintained until Nora moved toward and touched one of the squares with her nose, which qualified as her decision. When she chose correctly in both nonprobe and probe trials, a



**Figure 1.** Overhead view of experimental setups. A: Experiment 1. Nora was stationed behind the gate (gray line) on the central Tupperware container (asterisk) until the experimenter (solid circle) gestured to the left or right squares, generically indicated by the two pointing hands. B: Experiment 2. Commands were issued from center (solid circle) or off-center (gray circles) positions with relevant distances labeled. Hands are not depicted for off-center right to clarify the illustration. C: Experiment 3. Both left and right hands were used to point at ipsilateral and contralateral targets from all three positions. D: Experiment 4. Pointing gestures to three cubes labeled left (L), center (C), and right (R).

training clicker was pressed and a piece of herring immediately dispensed. Selection of the incorrect square in any trial caused the experimenter to say "no" firmly, turn his back on the subject, and walk away for 15–20 s.

## Results

Nora responded perfectly and spontaneously when upper body turns to the left and right were introduced in sessions preceding these experiments. Significance was determined by using a chi-square test to compare Nora's actual performance results with those expected if she were choosing randomly between left and right with a 50% success rate (see Figure 2a). P trials resulted in a performance significantly better than chance levels,  $\chi^2(1, N = 110) = 102.2, p < .001$ . Nora performed perfectly, and thus significantly better than expected by chance, on P+H,  $\chi^2(1, N = 18) = 18.0, p < .001$ , and UB trials,  $\chi^2(1, N = 18) = 18.0, p < .001$ . She moved immediately to the correct square when these signals were administered and responded appropriately during the first P+H and UB trials to the left and right.

No deviation from chance was detected for H,  $\chi^2(1, N = 18) = 3.6, p = .06$ , or E trials,  $\chi^2(1, N = 19) = 0.1, p = .82$ . Nora moved to the right on all H and E trials with the exception of a single E trial in which she moved left. She therefore responded correctly during the first H and E trials to the right but incorrectly during the first H and E trials to the left. She did not seem to detect these signals because her responses often lagged behind their delivery, suggesting her movement to the right served as a default response. Thirteen of the 18 H trials involved turning the head toward the right square, making her default decision seem correct more frequently (72%) than might be expected. Although it is difficult to tell whether a seal is making eye contact, the experimenter's head and arms were clearly within the seal's field of vision because she was looking up at the experimenter.

### Experiment 2: Center and Off-Center Pointing Cues

Pointing studies on other species have revealed significant performance biases resulting from differences in the location of the experimenter relative to the target objects (e.g., chimpanzees: Povinelli et al., 1997). A comparable study was conducted here to determine whether Nora was similarly influenced.

## Method

The setup and target objects were identical to those presented in Experiment 1. Six 30-trial sessions were completed April 19–25, 2002. A new probe trial pattern was used in which every 5 trials consisted of 3 centrally administered P trials as above and a combination of 2 off-center P, P+H, or H trials. In off-center trials, the gloved hand was either extended straight ahead toward the ipsilateral square or horizontally toward the contralateral square. Note that trials including head turns conducted while the experimenter was standing behind the target object did not include turns to the side but only a raising of the head from the starting position of looking down. The experimenter conducted these off-center trials while standing 1.3 m behind one of the white squares on the left or right, separating him from the distal object by 2.8 m (see Figure 1b). This location allowed the gloved hand in off-center trials to be closer to the ipsilateral square even when pointing to the contralateral square. Correct performance on these trials would thus refute a decision-making rule in which Nora selected the square closest to the glove.

The pointing sequence was pseudorandomized with half of the correct directions for every gesture category (i.e., center P, off-center P, off-center P+H, off-center H) indicating the left square and half the right square. In all sessions, 4 of the 12 probe trials were reserved for each of the three off-center commands. The pointing commands were maintained until Nora touched one of the squares with her nose. The reactions of the experimenter to correct and incorrect responses were identical to those described for Experiment 1.

## Results

The chi-square test was used again to assess Nora's performance (see Figure 2b). She performed significantly better than random in the center P trials,  $\chi^2(1, N = 109) = 109.0, p < .001$ ; the off-center P trials,  $\chi^2(1, N = 24) = 20.2, p < .001$ ; and the off-center P+H trials,  $\chi^2(1, N = 24) = 20.2, p < .001$ . Nora made only two mistakes in the off-center trials that included pointing, both when the experimenter stood on the right and pointed to the left. The results of the off-center H trials did not differ significantly from chance levels,  $\chi^2(1, N = 23) = 1.1, p = .30$ . Nora reacted correctly in the first off-center P and P+H trials but moved incorrectly in the first off-center H trial. With the exception of one trial in which she moved left, all of Nora's errors during the H trials were made because she moved right regardless of the actual direction of the head turn. Occasionally before an off-center trial was initiated or during the stationing phase of one of these trials, Nora would move to the square in front of where the experimenter was standing. Although each trial would only commence once she returned to the central Tupperware container, she did seem to be partially influenced by the asymmetrical position of the experimenter. This was not reflected in her actual selection of the appropriate square, however.

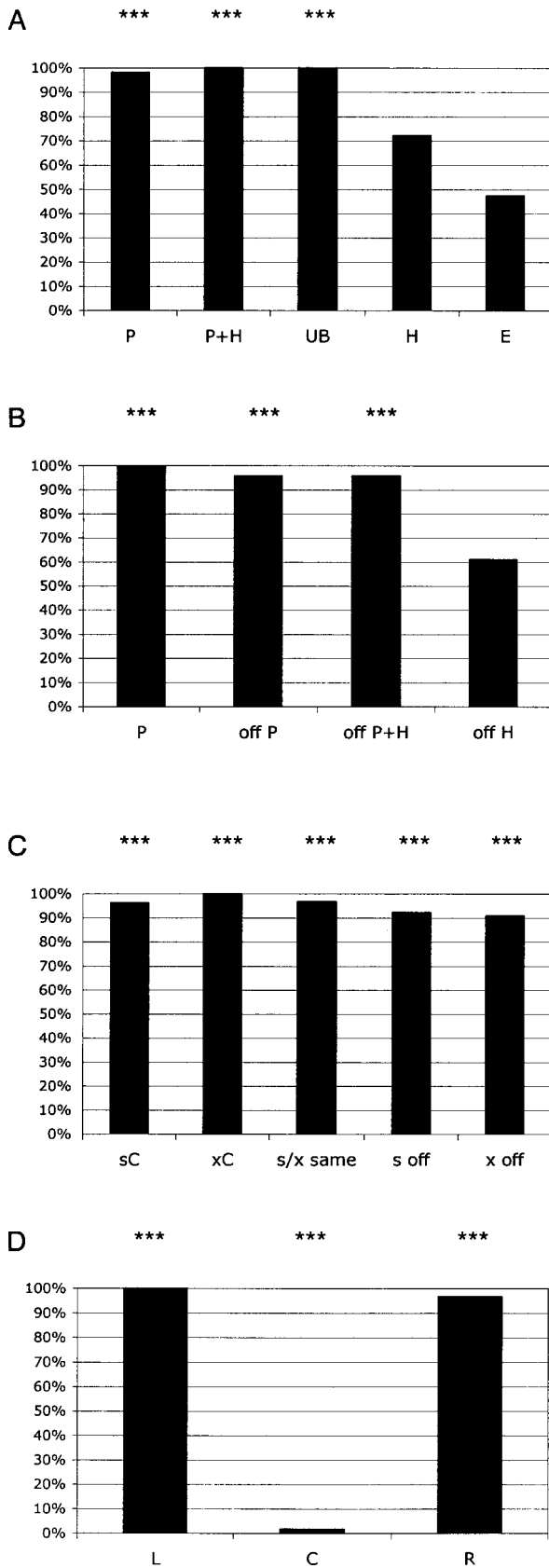
### Experiment 3: Examining Signal Duration and Ipsilateral and Contralateral Hand Usage

Herman et al. (1999) suggested pointing gestures of a shorter duration produced by both left and right hands were most appropriate for these kinds of studies. Leaving the hand suspended in the direction of the correct target object in Experiments 1 and 2 might have allowed Nora to visually consult the signal repeatedly, updating her orientation accordingly as she moved toward one of the squares. If so, she may have concentrated on the overall configuration of the visual stimulus consisting of the target object and the outstretched arm of the experimenter. A correct response after a brief pointing signal would indicate that the seal could use the pointing signal alone to respond correctly. The introduction in this experiment of pointing with the left hand assessed how sensitive Nora's reactions were to the specific region of the experimenter's body dispensing the signal.

## Method

No changes were made to the experimental setup or target objects specified in Experiments 1 and 2. Each of six sessions conducted between April 27, 2002 and May 9, 2002 contained 30 P trials. The experimenter stood centrally in 10 trials, off-center to the left in 10, and off-center to the right in the remaining 10 in the same positions described for Experiment 2. The left and right green gloved hands each introduced half of the trials. The correct response was to the left in 15 of these trials and to the right in the other 15. The order of these last two variables (i.e., left or right hand, left





or right square) was randomized to balance the relative quantities of each option for the three possible positions of the experimenter. After the name of the subject was called and she stationed at the Tupperware container, all pointing signals were brief (< 1 s) and were terminated by an immediate return of the gesturing arm to the side of the experimenter (see Figure 1c). Nora's decision was taken to be the first white square she touched with her nose. The experimenter responded to Nora's correct and incorrect decisions as in Experiment 1.

The resulting command sequence produced five categories suitable for analysis. The first two concerned the centrally located experimenter signaling the square by pointing with his ipsilateral arm (sC) or contralateral arm (xC), requiring his arm to move across the front of his chest. Off-center points with either hand to the target object directly in front of the experimenter constituted the third category (s/x same). Points to the square on the side opposite the off-center experimenter were either made with the ipsilateral arm (s off) or the contralateral arm (x off), again causing the arm to pass in front of the chest.

**Results**

A chi-square test revealed that the results from all analysis categories were significantly above the values expected from random guessing (see Figure 2c): sC,  $\chi^2(1, N = 26) = 22.2, p < .001$ ; xC,  $\chi^2(1, N = 33) = 33.0, p < .001$ ; s/x same,  $\chi^2(1, N = 60) = 52.3, p < .001$ ; s off,  $\chi^2(1, N = 38) = 27.0, p < .001$ ; x off,  $\chi^2(1, N = 22) = 14.7, p < .001$ . All pointing conditions produced a correct response in the first trial except for the first center and off-center ipsilateral points to the left square. No errors were made on the second of such trials, however.

All nine mistakes in this experiment were again made because Nora incorrectly selected the right square. Seven of these errors occurred when the left arm gave the command to touch the left square. Nora moved erroneously the first two times the left arm was used to point to the left in the first session and in the first trial of the second session that began almost a week later. Nora's default decision to move right seemed on occasion to override the dramatic pointing gestures to the left. Because the position of the pointing arm was maintained only momentarily before being withdrawn, Nora's correct decisions were not made by continuously consulting the direction of the pointing arm as she moved.

**Experiment 4: Probing Nora's Comprehension of the Pointing Gesture**

It is possible in the previous experiments that Nora simply followed the direction of movement of the pointing signal, stopping after finding a target object. This experiment introduced a

*Figure 2.* Percentage correct responses for all experiments. A: Experiment 1. Pointing (P), pointing and head turning (P+H), upper body turning (UB), head turning (H), and gazing (E) trials. B: Experiment 2. Center pointing (P), off-center pointing (off P), off-center pointing and head turning (off P+H), and off-center head turning (off H) trials. C: Experiment 3. Centrally administered points to the square with the ipsilateral (sC) or contralateral (xC) arm, off-center points with either hand to the square in front of the experimenter (s/x same), and off-center points to the opposite square with the ipsilateral (s off) or contralateral (x off) arm. D: Experiment 4. Points to the left (L), central (C), and right (R) cubes. \*\*\* $p < .001$ .

third object and moved all three objects behind Nora to investigate how well she responded to pointing gestures requiring her to swim beyond the target objects closest to her. The overall design is similar to Experiment 1 in Herman et al. (1999).

### Method

*Experimental setup and target objects.* This experiment was conducted in the larger of the two circular pools (5 m diameter). The Tupperware container was suspended 0.2 m above the surface of the pool and 0.8 m from the edge. Three cubes (side length of 15 cm) made from white corrugated plastic were placed in the water and tied along the edge of the pool behind and to the left (again from the perspective of the experimenter) of the Tupperware container, directly behind the Tupperware container, and behind and to the right of the Tupperware container (see Figure 1d).

*Procedure.* In a single day, Nora was trained to station on the Tupperware container in the pool by treading water beneath it. Six sessions of 30 trials each were conducted May 11–16, 2002. The experimenter stood on land in front of the Tupperware container. Each trial began with the experimenter articulating the subject's name and slowly lowering his head to his chest. The experimenter pointed with his right, gloved arm (index finger extended) to the cube determined by a randomized sequence of 10 points to the left, 10 to the center, and 10 to the right. Each point was accompanied by the experimenter lifting and turning his head in the direction of the pointing arm and focusing his eyes on the appropriate target. The experimenter exaggerated the central points a bit by leaning slightly forward. Because the cubes were located behind Nora's stationing position, she could not visualize these targets until she turned in response to the pointing commands.

The first trial was a point to the central cube, but Nora swam incorrectly to the left cube. Several points to the left cube were required in the second trial before she swam away from the Tupperware container in the correct direction. This delayed response probably resulted from the new experimental setup, Nora not knowing she had to touch her nose to one of the cubes, and her incorrect decision on the first trial. For all remaining trials, the experimenter pointed at the correct cube with his arm and oriented his head and eyes similarly until Nora touched one of the cubes with her nose. Herring rewards were tossed into the water for correct responses. After an incorrect response, the experimenter said "no" as he turned and walked away from the pool for 15–20 s, carrying the fish bucket with him to prevent Nora from helping herself to its contents.

### Results

All results were significantly different than expected from a random selection model in which Nora would choose indiscriminately among the cubes, selecting each one third of the time on average. A chi-square test (see Figure 2d) indicated that, although Nora chose correctly more often than expected, when the experimenter pointed to the left,  $\chi^2(1, N = 60) = 270.0, p < .001$ , and right cubes,  $\chi^2(1, N = 60) = 246.6, p < .001$ , she chose incorrectly more frequently than expected when the central cube was indicated,  $\chi^2(1, N = 60) = 84.2, p < .001$ . Nora moved correctly in response to the first point to the left cube but incorrectly to the first points to the center and right cubes. The second point to the right cube did produce the correct movement.

Nearly all of Nora's mistakes (59 out of 61) occurred when the pointing gesture was directed at the central cube. She only selected the central cube correctly on one of the first few trials in the first session. When the experimenter pointed at the central cube, Nora most frequently swam to the left ( $N = 45$ ). The experimenter twice extended his arm just right of center when indicating this central

cube, and Nora selected the right cube in these trials. A consistent return on central trials to the lateral cube most recently indicated was not evident. Nora preferentially selected the left and right targets, ignoring the central cube behind her.

### General Discussion

Nora, a 5- to 6-month-old gray seal, was trained successfully to discriminate between moving to touch a square on the left or right in response to pointing gestures. She was then tested on pointing and head turning together and upper body turning administered from a central position. She generalized her responses successfully to these cues. However, her performance dropped to chance levels when the correct square was indicated solely by head turning or gazing. Nora also performed significantly above chance when pointing gestures alone and with corresponding gaze were introduced from off-center locations. Off-center head turning trials witnessed a return to chance levels. These results are strikingly better than those of similar experiments attempted with chimpanzees, which apparently based their selection on the proximity of the gesturing experimenter to the object (Povinelli et al., 1997). In off-center trials, the head turn seemed to help the chimpanzees to select the correct object more than the pointing cues, a finding opposite to that found with Nora. Such differences may have arisen, however, from subtle discrepancies in the initial training procedure and therefore do not necessarily indicate variation among species.

Nora also discriminated spontaneously between pointing gestures made rapidly and with both ipsilateral and contralateral arms to select the left or right square appropriately. The displacement of the cubes outside of Nora's visual field and the introduction of a third cube directly behind the stationing target produced mixed results. She touched the left and right cubes significantly above chance levels but only once selected the central cube out of 60 trials.

On land, Nora's mistakes were most frequently made because she moved to the right when she should have touched the left square. On head turning and gazing trials she nearly always moved to the right, suggesting she was unable to discern these more subtle signals, and selected the right square as her default option. This could have been caused by the use of the right hand in the initial training or by the fact that the food reward was given with the right hand. In the water, however, Nora selected the left cube in 45 of the 60 trials in which the central cube was the correct choice. She seemed sensitive to minimal changes in the placement of this central pointing gesture with slight displacements to the right occasionally leading her to select the right cube. The last two sessions contained several central cube trials in which Nora started swimming to one of the laterally placed cubes but returned to the Tupperware container before dashing off to the opposite cube. Her indecision about where to proceed on these trials was evident, suggesting that her poor performance did not result from an inability to resolve the direction of the pointing arm but rather from not understanding the referential association of a central point with the central cube.

Taken together, our observations indicate that salient, laterally directed movements of the experimenter provided Nora with the information necessary to orient left or right and move accordingly. The pointing gesture, however brief, was more meaningful to Nora

in this decision-making process than the position of the experimenter relative to center. Nora's performance can be explained as a result of simple discriminative learning without invoking any referential understanding of the pointing commands. Her failure in the trials requiring her to select the central cube was particularly striking in this regard. An advantage of our setup was the full record of all interactions that Nora had with humans. Prior to this study, Nora was not involved in any other training procedures and had only been in captivity for a few months. It is possible that Nora ignored head or gaze cues because our initial training concentrated exclusively on pointing. However, her minimal experience with humans and the obvious differences between seal and human would have made her responding to these clues surprising.

It is compelling that a gray seal was capable of responding to human directional gestures at all. Pinnipeds have not been reported to point with their flippers or other regions of their bodies. The extent to which gray seals forage and travel in groups in the water remains unknown, but the similar movement patterns and activity budgets within gray seal age groupings (Hammond, McConnell, & Fedak, 1993) suggest that certain species of pinnipeds may engage in following and imitative social behavior. It is possible in these contexts that seals use the body orientation and posture of conspecifics to determine their own swimming direction. Nora's correct reaction to movements involving the displacement or rotation of a large and conspicuous region of the experimenter's body (i.e., pointing, pointing and head turning, and upper body turns) might have emerged as a byproduct of this ability to attend to the gross alignment of the bodies of conspecifics. Alternatively, simple conditioning could also explain the results presented here.

The body of literature on pointing experiments represents a blend of opinions. Some researchers argue for referential comprehension and possible implications for theory of mind. Others offer a more cautious explanation of why certain species lacking a rich cognitive understanding of the mental states and perspectives involved might still perform successfully on these tasks. Conflict exists even about whether human infants possess theory of mind as these abilities develop. Some have stressed its inevitability (Leung & Rheingold, 1981), and others have emphasized its absence (Butterworth & Jarrett, 1991). The evidence gathered from this study suggests the cautious approach might be a more appropriate view from which to regard most of these studies.

Several experimenters have claimed that bottlenose dolphins (Tschudin et al., 2001) and domesticated dogs (Miklósi et al., 1998; Miklósi, Polgárdi, Topál, & Csányi, 2000; Soproni et al., 2001) have used interspecific communication with human beings to perform successfully on pointing tasks. Tschudin et al. (2001) presented findings that out of 6 captive bottlenose dolphins, 3 performed above chance during a set of initial pointing trials and 2 during head-turning trials. Soproni et al. (2001) suggested that dogs used a referential component and attentional cue to select the correct object when an experimenter turned her head and looked at this target. Finally, Miklósi et al. (1998) introduced different lateral gestures in increasingly subtle cueing trials along a continuum of pointing, bowing, nodding, head turning, and gazing. Given enough time, the subjects performed significantly above chance for all cues.

The performance of the dolphins and dogs in these studies resulted from their successful discrimination between two symmetrical (albeit subtle at times) cues to determine whether a

movement to the left or right would secure a reward. A consistent and spontaneous correct performance was absent in these studies when the novel, increasingly subtle cues were introduced. It is likely that no interspecific communication was present beyond the usual information conveyed by discriminative conditioning. Experiments in which the subject had a lot of unrecorded previous interaction with humans are difficult to interpret. Training might have taken place inadvertently at an earlier stage, and claims of higher cognitive mechanisms are therefore not convincing.

Call and Tomasello (1994) have discussed how Chantek, an enculturated orangutan, better understood novel pointing scenarios and the attention-directing character of pointing than an orangutan named Puti raised in captivity with other orangutans. Although Call and Tomasello (1994) speculated that Chantek viewed humans as intentional beings whose attention can be controlled and exploited, the work of Povinelli and deBlois (1992) casts doubt on this interpretation. Three-year-old humans were unable to offer a rationale for why they looked under the cup pointed to by an experimenter, whereas 70% of the 4-year-olds could state that they observed the experimenter "show," "tell," or "point" to the correct cup (Povinelli & deBlois, 1992). Taken alone, it is possible to interpret the behavior of the 3-year-olds as a result of simple conditioning. The 4-year-olds revealed that this understanding appears at a particular developmental stage, rendering the behavior of the 3-year-olds more insightful. Thus, although Chantek behaved correctly, he might have lacked an understanding of why he chose appropriately and of the corresponding intentional stance of his human interlocutors.

Other experiments testing the responses of primates to directional cues given by an experimenter have been more restrained in their interpretations of the successful results. A female rhesus macaque was trained to point to the one tray among three containing food to inform a naive human experimenter. The macaque performed quite poorly when the roles were reversed and she was expected to respond to the pointing of the experimenter, suggesting her pointing behavior was a conditioned response to the training (Hess, Novak, & Povinelli, 1993). Itakura and Tanaka (1998) explained the understanding of tapping, pointing, head-turning, and gazing cues by chimpanzees, orangutans, and human infants between 18 and 27 months as a simple, noncognitive association between head, eye, and postural orientation and the appropriate object. Similar results in gorillas with the exception of the glancing cues were accounted for as a result of the spatial proximity of the cue to the object without any referential understanding (Peignot & Anderson, 1999). Chimpanzees tracked the head orientation and gaze of an experimenter behind them, but Povinelli and Eddy (1997) argued for an absence of a comprehension of intentionality, the tendency found in humans to assign motivations and goals to animate objects in the physical world. The neural resources of primates (and possibly other mammals) dedicated to these tasks of monitoring gaze and head orientation (e.g., Kawashima et al., 1999; Perrett et al., 1985) do not necessitate the corresponding cognitive comprehension of their implications for perspective sharing and theory of mind. Instead, they may have arisen because of the selective benefit of being able to access visually relevant social and physical features of their environment.

Herman et al. (1999) introduced the test that we used in Experiment 4 in which pointing was transferred to a novel object in a new location behind the animal. In their study, 1 bottlenose dol-

phin did not perform successfully in this task but could be trained to respond to a third object. However, a second dolphin did respond spontaneously to the object in the novel position albeit making more mistakes than in trials to the left or the right. We assume that Nora could have been trained according to this paradigm as well, but only spontaneous reactions were tested in this study. The study of Herman et al. demonstrates how important it is to test more than 1 subject. Thus, we cannot conclude that seals are not capable of performing in this trial. Although the subjects used by Herman et al. had frequent exposure to training and experience in other object-related tasks, the performance of the second dolphin seemed to indicate a more advanced understanding of the pointing gesture than demonstrated in other studies. This kind of experiment clearly needs to be applied more widely because it controls for the conditioning effects that we discussed above.

The results of the experiments presented here and the majority of other pointing studies are most parsimoniously explained as stemming from simple conditioning that does not infer a higher level of cognitive understanding of the tasks at hand. The pointing literature would benefit greatly from studies in which success is only possible through the very referential comprehension many are hoping to find and not through mere lateral discrimination of physically symmetrical directional commands.

#### References

- Anderson, J. R., & Mitchell, R. W. (1999). Macaques but not lemurs co-orient visually with humans. *Folia Primatologica*, *70*, 17–22.
- Anderson, J. R., Sallaberry, P., & Barbier, H. (1995). Use of experimenter-given cues during object-choice tasks by capuchin monkeys. *Animal Behaviour*, *49*, 201–208.
- Anderson, S. R., & Keenan, E. L. (1985). Deixis. In T. Shopen (Ed.), *Language typology and syntactic description* (Vol. 3, pp. 259–308). Cambridge, England: Cambridge University Press.
- Bonner, N. (1972). The grey seal and common seal in European waters. *Oceanography and Marine Biology Annual Review*, *10*, 461–507.
- Butterworth, G., & Jarrett, N. (1991). What minds have in common is space: Spatial mechanisms serving joint visual attention in infancy. *British Journal of Developmental Psychology*, *9*, 55–72.
- Call, J., Hare, B. A., & Tomasello, M. (1998). Chimpanzee gaze following in an object-choice task. *Animal Cognition*, *1*, 89–99.
- Call, J., & Tomasello, M. (1994). Production and comprehension of referential pointing by orangutans (*Pongo pygmaeus*). *Journal of Comparative Psychology*, *108*, 307–317.
- De Waal, F. B. M. (2001, January 19). Pointing primates: Sharing knowledge—without language. *The Chronicle of Higher Education*, p. B7.
- Emery, N. J., Lorincz, E. N., Perrett, D. I., Oram, M. W., & Baker, C. I. (1997). Gaze following and joint attention in rhesus monkeys (*Macaca mulatta*). *Journal of Comparative Psychology*, *111*, 286–293.
- Hammond, P. S., McConnell, B. J., & Fedak, M. A. (1993). Grey seals off the east coast of Britain: Distribution and movements at sea. *Symposia of the Zoological Society of London*, *66*, 211–224.
- Hare, B. A., & Tomasello, M. (1999). Domestic dogs (*Canis familiaris*) use human and conspecific social cues to locate hidden food. *Journal of Comparative Psychology*, *113*, 173–177.
- Herman, L. M., Abichandani, S. L., Elhajj, A. N., Herman, E. Y. K., Sanchez, J. L., & Pack, A. A. (1999). Dolphins (*Tursiops truncatus*) comprehend the referential character of the human pointing gesture. *Journal of Comparative Psychology*, *113*, 347–364.
- Hess, J., Novak, M. A., & Povinelli, D. J. (1993). “Natural pointing” in a rhesus monkey, but no evidence of empathy. *Animal Behaviour*, *46*, 1023–1025.
- Itakura, S., & Tanaka, M. (1998). Use of experimenter-given cues during object-choice tasks by chimpanzees (*Pan troglodytes*), an orangutan (*Pongo pygmaeus*), and human infants (*Homo sapiens*). *Journal of Comparative Psychology*, *112*, 119–126.
- Kawashima, R., Sugiura, M., Kato, T., Nakamura, A., Hatano, K., Ito, K., et al. (1999). The human amygdala plays an important role in gaze monitoring: A PET study. *Brain*, *122*, 779–783.
- Leung, E. H. L., & Rheingold, H. L. (1981). Development of pointing as a social gesture. *Developmental Psychology*, *17*, 215–220.
- McKinley, J., & Sambrook, T. D. (2000). Use of human-given cues by domestic dogs (*Canis familiaris*) and horses (*Equus caballus*). *Animal Cognition*, *3*, 13–22.
- Miklósi, Á., Polgárdi, R., Topál, J., & Csányi, V. (1998). Use of experimenter-given cues in dogs. *Animal Cognition*, *1*, 113–121.
- Miklósi, Á., Polgárdi, R., Topál, J., & Csányi, V. (2000). Intentional behaviour in dog-human communication: An experimental analysis of “showing” behaviour in the dog. *Animal Cognition*, *3*, 159–166.
- Peignot, P., & Anderson, J. R. (1999). Use of experimenter-given manual and facial cues by gorillas (*Gorilla gorilla*) in an object-choice task. *Journal of Comparative Psychology*, *113*, 253–260.
- Perrett, D. I., Smith, P. A. J., Potter, D. D., Mistlin, A. J., Head, A. S., Milner, A. D., & Jeeves, M. A. (1985). Visual cells in the temporal cortex sensitive to face view and gaze direction. *Proceedings of the Royal Society of London, Series B*, *223*, 293–317.
- Povinelli, D. J., Bierschwale, D. T., & Cech, C. G. (1999). Comprehension of seeing as a referential act in young children, but not juvenile chimpanzees. *British Journal of Developmental Psychology*, *17*, 37–60.
- Povinelli, D. J., & deBlois, S. (1992). Young children’s (*Homo sapiens*) understanding of knowledge formation in themselves and others. *Journal of Comparative Psychology*, *106*, 228–238.
- Povinelli, D. J., & Eddy, T. J. (1997). Specificity of gaze-following in young chimpanzees. *British Journal of Developmental Psychology*, *15*, 213–222.
- Povinelli, D. J., Nelson, K. E., & Boysen, S. T. (1990). Inferences about guessing and knowing by chimpanzees (*Pan troglodytes*). *Journal of Comparative Psychology*, *104*, 203–210.
- Povinelli, D. J., Reaux, J. E., Bierschwale, D. T., Allain, A. D., & Simon, B. B. (1997). Exploitation of pointing as a referential gesture in young children, but not adolescent chimpanzees. *Cognitive Development*, *12*, 423–461.
- Scaife, M., & Bruner, J. S. (1975, January 24). The capacity for joint visual attention in the infant. *Nature*, *253*, 265–266.
- Soproni, K., Miklósi, Á., Topál, J., & Csányi, V. (2001). Comprehension of human communicative signs in pet dogs (*Canis familiaris*). *Journal of Comparative Psychology*, *115*, 122–126.
- Tomasello, M., Call, J., & Gluckman, A. (1997). Comprehension of novel communicative signs by apes and human children. *Child Development*, *68*, 1067–1080.
- Tomasello, M., Call, J., & Hare, B. A. (1998). Five primate species follow the visual gaze of conspecifics. *Animal Behaviour*, *55*, 1063–1069.
- Tschudin, A., Call, J., Dunbar, R. I. M., Harris, G., & van der Elst, C. (2001). Comprehension of signs by dolphins (*Tursiops truncatus*). *Journal of Comparative Psychology*, *115*, 100–105.

Received August 5, 2002

Revision received December 29, 2002

Accepted January 4, 2003 ■