

Use of experimenter-given cues by African gray parrots (*Psittacus erithacus*)

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Abstract One advantage of living in a social group is the opportunity to use information provided by other individuals. Social information can be based on cues provided by a conspecific or even by a heterospecific individual (e.g., gaze direction, vocalizations, pointing gestures). Although the use of human gaze and gestures has been extensively studied in primates, and is increasingly studied in other mammals, there is no documentation of birds using these cues in a cooperative context. In this study, we tested the ability of three African gray parrots to use different human cues (pointing and/or gazing) in an object-choice task. We found that one subject spontaneously used the most salient pointing gesture (looking and steady pointing with hand at about 20 cm from the baited box). The two others were also able to use this cue after 15 trials. None of the parrots spontaneously used the steady gaze cues (combined head and eye orientation), but one learned to do so effectively after only 15 trials when the distance between the head and the baited box was about 1 m. However, none of the parrots were able to use the momentary pointing nor the distal pointing and gazing cues. These results are discussed in terms of sensitivity to joint attention as a prerequisite to understand pointing gestures as it is to the referential use of labels.

Keywords African gray parrots (*Psittacus erithacus*) · Gaze · Heterospecific communication · Object-choice · Pointing · Referential signals

Introduction

One advantage of living in a social group is having access to information provided by conspecifics, to locate predators and food sources, for example (Danchin et al. 2004). Social information can be based on cues provided inadvertently or advertently by the actions of an individual. Such information can be used to assess the relative quality of contestants by eavesdropping, i.e., gathering information from signaling interactions of conspecifics (McGregor and Dabelsteen 1996). Animals can also use social cues provided intentionally or unintentionally by only one individual such as the direction of a conspecific's gaze or its vocalizations (Anderson 1998; Evans 1997). Moreover, it appears that the direction of individual's gaze could be informative not only between conspecifics, but also between animals and humans. Following human gaze is a skill that seems to be widespread among nonhuman primates (Tomasello et al. 1998). There is also some evidence of human gaze-following in other mammals, such as dogs (Miklósi et al. 1998), dolphins (Tschudin et al. 2001) and goats (Kaminski et al. 2005). In all of these studies, species tested were able either to use human gaze to find hidden food items in one of several containers (Barth et al. 2005; Miklósi et al. 1998; Tschudin et al. 2001) or to co-orient their gaze above, behind and even around barriers (Call et al. 1998; Tomasello et al. 1999). These abilities involve more or less sophisticated cognitive skills, with visual co-orientation seemingly less demanding than using human gaze to locate hidden items (Gómez 2005): some species, such as goats

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and monkeys, readily visually co-orient and yet do not use gaze effectively to discriminate between objects (Kaminski et al. 2005; Vick and Anderson 2003).

In addition, another source of information has been shown to be used by some animals: the pointing gesture. Human pointing is a referential signal that can be used to indicate anything in the environment. The use and the understanding of pointing gestures as a social and a communicative cue occur early in human development (Bates et al. 1977 quoted in Miklósi and Soproni 2006; Povinelli et al. 1997). Nonhuman animals' understanding of pointing, as evaluated in an object-choice task paradigm, varies according to the form of pointing gesture, the species and the individuals' past experience (Itakura et al. 1999; Itakura and Tanaka 1998; Miklósi and Soproni 2006). In this task, food is hidden in one of two (sometimes more) bowls, which are placed either on the floor or on a table, in front of the subject. The experimenter stands between the bowls and points to the baited bowl (sometimes, with additional cues such as gaze, i.e., head and/or eyes orientated toward the target). The pointing gesture is either static (the experimenter points prior to the beginning of the trial and stays in this position until the subject makes its choice), momentary (the experimenter initiates the pointing at the start of the trial and points to the target momentarily), or dynamic (the experimenter moves their arm at the start of the trial and stays in this position until the subject makes its choice, (Miklósi and Soproni 2006). Among apes, chimpanzees (*Pan troglodytes*) are able to find the baited bowl when it is pointed to and, in some experiment when it is gazed at (Call et al. 1998; Itakura and Tanaka 1998; Povinelli et al. 1997); gorillas (*Gorilla gorilla*) are also competent when the baited bowl is just pointed to (Peignot and Anderson 1999); results with orangutans are inconsistent (*Pongo pygmaeus*; Call et al. 1998; Call and Tomasello 1994; Tomasello et al. 1997). Results are also divergent among monkeys: for example, capuchin monkeys (*Cebus apella*) spontaneously comprehend the pointing gesture (Anderson et al. 1995), but rhesus monkeys (*Macaca mulatta*) fail to do so (Anderson et al. 1996). The problem with this comparison between species is that the methods (gestures, etc.) often vary. Interestingly, dogs (*Canis familiaris*) seem to outperform primates on these tasks. Dogs spontaneously comprehend both pointing or gazing to locate hidden food (Hare and Tomasello 1999; McKinley and Sambrook 2000; Miklósi et al. 1998; Soproni et al. 2001, 2002), contrary to wolves (*Canis lupus*), which are only able to comprehend some of these cues after being socialized with humans (Hare et al. 2002; Virányi et al. 2008). This ability seems to have been under selection during the process of domestication (Hare et al. 2002; Miklósi et al. 2003). Hare et al.'s (2005) finding that experimentally domesticated foxes (*Vulpes vulpes*; bred over 45 years to approach humans

fearlessly and nonaggressively) are better than control foxes (not selected for their behavior) in pointing and gazing to locate hidden food provides some support to this hypothesis (Hare et al. 2005). Horses (*Equus caballus*), kept in a riding school, which are another class of domestic species, are also able to follow various pointing cues (Maros et al. 2008). Overall, it appears that domesticated species and some nondomesticated but human-reared apes are able to comprehend human-given cues, contrary to non-domesticated, nonhuman-reared animals (Hare et al. 2005; Kaminski et al. 2005). Note, however, that any such species comparison is hampered by the fact that the cues used by humans varied across the different species (Miklósi and Soproni 2006).

In contrast to domesticated mammals' or nondomesticated but human-reared apes' abilities to use human gaze and pointing gestures, it appears that little is known about nondomesticated species' abilities, particularly birds, to follow either human gaze or pointing gestures. Some bird species adjust their behavior according to the gaze direction of a conspecific or a human intruder, but only in a competitive (as opposed to cooperative) way. Scrub-jays (*Aphelocoma californica*), for example, recached food in new cache sites when they had been observed caching by a conspecific (Emery and Clayton 2001; Emery et al. 2004). Bee-eaters (*Merops orientalis*) entered their nest more frequently when a human was looking away or was unable to see the nest (Smitha et al. 1999; Watve et al. 2002). Ravens (*Corvus corax*) follow the gaze direction of a human and co-orient with them towards distant locations, even behind barriers (Bugnyar et al. 2004), but have difficulties with human-given visual cues in object-choice tasks (Schloegl et al. 2008).

Most parrots live in complex fission–fusion societies: foraging in smaller groups when in the trees, and in large groups when on the ground where they are more vulnerable (Bradbury 2003). During foraging, a member of the flock perches and calls at the approach of danger (e.g., Yamashita 1987). It could therefore be adaptive to use information provided by conspecifics, such as their gaze or vocalizations, to localize a potential predator, for example. In addition, African gray parrots (*Psittacus erithacus*) are known for their sophisticated cognitive abilities. For the past 30 years, Pepperberg and her colleagues have taught an African gray, Alex, to understand and produce English labels. Alex knew several labels referentially; he was able to categorize attributes inherent to an object; he can understand abstract concepts that are same/different; he was also able to count upto six [for a recent review, see (Pepperberg 2006)]. These abilities lead Pepperberg to emphasize that the combination of intelligence and advanced communication skills may have arisen not only in primates or even in mammalian lines, but also in avian lines such as in parrots

(Pepperberg 1999). Pepperberg and McLaughlin (1996) also demonstrated the importance of joint attention to the referential learning of labels by gray parrots. They demonstrated that, without joint attention, two parrots were not able to referentially learn human labels, though they were able to learn with an interaction between trainee and trainer. Joint attention also appears to be an important feature in the language acquisition process in humans (e.g., Baldwin 1991; Dominey and Dodane 2004). Thus, we can expect that parrots able to referentially learn labels are sensitive to joint attention.

Although African gray parrots are not a domesticated species (they had been bred in captivity for only a few generations), hand-reared grays are fully habituated to interact with humans and are largely exclusive toward one person (Schmid et al. 2006). Thus, they could be particularly sensitive to gestures of their main caretaker. To investigate whether African gray parrots can use human cues, we tested three hand-reared African grays using four types of pointing (see “Materials and methods”) described by Miklósi (Miklósi and Soproni 2006). Then, we go further into our results by subdividing the components of the pointing cues.

These parrots spent most of their time in human company, with the two main experimenters (DB and NG, see “Materials and methods”) since their arrival at the laboratory. During everyday interactions, we took care to avoid training them with cues tested in these experiments, but we cannot exclude that parrots would have been familiarized with similar cues in our everyday interactions (e.g., association between gaze and food and/or between hand and food).

The protocol used here was designed to study abilities in parrots in a manner that is comparable to similar experiments conducted in other species. In this study, we evaluated the capacities of previously untrained African gray parrots to spontaneously use different human pointing gestures and/or to follow the human gaze to locate hidden food. At the start of the experiment, one bird (Zoé) had already referentially learned human labels, but the others not. Thus, we expected that at least this particular bird would be sensitive to joint attention and thus will be able to use the cues presented.

Materials and methods

Subjects and housing conditions

Three nonconsanguine, captive hand-reared African gray parrots (*Psittacus erithacus*) were used in this study: Zoé (female), Léo (male) and Shango (male). Hand-rearing for parrots means that the parrots were fed by their parents during their first 15 days and thereafter by a human caretaker. The three parrots were acquired at 3 months of age. All

training and testing occurred in their indoor aviary ($340 \times 330 \times 300 \text{ cm}^3$), where they are housed together, during two sessions in June and October 2006 (Zoé and Léo were 35 months old and Shango was 12 months old at the time of the first session). In the aviary, the birds are maintained in constant annual photoperiod 12:12 (light:dark; UV light) and at 25°C . They are showered and have the possibility to take a bath every morning. Their aviary is furnished with two large wooden structures with perches ($70 \times 103 \times 200 \text{ cm}^3$), two tables (on which training and tests sessions were presented, see “Apparatus”) and various small toys. When a subject was tested, the two others were taken (in a small transport box) to another room ($410 \times 245 \times 270 \text{ cm}^3$) in which they are also provided with toys, perches and UV light. The birds were food-deprived for 2 h before training and test sessions, but for the rest of the time, they were fed ad libitum with parrot pellets (Nutribird P15), and fresh fruits and parrot porridge (Nutribird A21) were given once a day. Water was always available ad libitum.

Apparatus

Experimenter 1 stood equidistant (0.60 m) between two tables (0.75 m height). Two identical yellow opaque boxes (12 cm height, 10 cm of diameter) were put on the tables, which were 1.6 m apart. Lids were used to hide the contents of the box. The subject was placed in a holding cage ($45 \times 31 \times 30 \text{ cm}^3$) on a third table (0.75 m height), 2.15 m away from both boxes. This holding cage had one aperture, which could easily be blocked with a screen by experimenter 2. During training and testing of a parrot, the two others were put in another room.

Previous testing experience

The parrots were tested on two tasks of object-permanence using the same apparatus. In the first phase, after trying to obtain the attention of the subject, experimenter 1 put seeds in one of the two boxes, without coming into contact with the other box. Then, experimenter 2 released the parrot, who was then free to fly to a box. About 40 sessions (10 trials per session) were carried out. The procedure of the second phase was the same as the first one, except that either before or after putting the seeds in one of the boxes, experimenter 1 showed the empty box to the subject. Twenty sessions (10 trials per session) were done. In these two tasks, parrots never saw the experimenters making any pointing gestures.

Training

To familiarize the parrots with the basic task requirements (knowing that seeds can be contained in one of the boxes),

training sessions were conducted prior to testing with cues. Experimenter 1 placed seeds in and in front of one of the two boxes (to attract the parrot near one of the boxes so that he can see that seeds are in the box) so that the parrot was able to see the seeds. The experimenter 2 then released the parrot, who was then free to fly to either of the two boxes. Flying to the side with a box containing seeds and with seeds near this box (correct response) was rewarded with 30 s of access to the food (that was in front or in the box) and praise, while flying to the empty box was considered as an incorrect response. In this case, the parrot was allowed to see the content of the empty box but not of the baited one. All other kinds of responses, such as no response (the subject did not leave their holding cage) or flying to another place (such as on to an experimenter), were considered as null trials. The subject was then brought back to the starting point and put in his small cage by experimenter 1. The aperture of the small cage was then obstructed with the sheet, so that the parrot was in the dark for 20 s before the following trial began. Ten trials per session were presented, with one session per day, 5 days a week. Test trials started when subjects had reached 80% of correct responses during three consecutive sessions.

General procedure

Experimenter 1 hid seeds in one of the two boxes out of subject's sight. Then, experimenter 2 allowed the subject to see experimenter 1 (by retracting the sheet). Experimenter 1 called the subject to gain their attention while enacting a specific cue (see below and Table 1 for a description of the different kinds of cues). After cueing, the subject was released and allowed to make a choice. As in training, choosing the baited box was rewarded with 30 s of access to the seeds and verbal praise; the subject was prevented from receiving any food if they chose the empty box. If the subject did not respond within 30 s of cue presentation, experimenter 1 re-enacted the cue for the second time. If the subject still did not respond, the trial was considered as null. The subject was then put in the holding cage for 20 s before restarting the trial. If the subject did not respond for two consecutive trials, sessions were abandoned until the next day.

Test 1: distal momentary pointing

During the first testing phase, the experimenter 1 stood at 2 m from each boxes and enacted a distal momentary pointing (dmp) as a cueing gesture, i.e., looked the subject in the eyes and pointed to the baited box for a short time (arm and index held out for about 2 s), after which she replaced her arm alongside her body. During pointing, the distance between the tip of the index finger and the baited box was

about 1 m. After pointing, the experimenter continued to look at the subject.

Twenty trials in total (usually 10 trials a day unless the parrot was not motivated enough) were presented. The order of baiting was pseudorandom with the baited box on the right side for half of the trials and on the left side for the other half, but with no more than two successive times on the same side.

Test 2: mixed pointing

In test 2, we tested three other types of pointing in random order within the same sessions: distal dynamic-sustained pointing (ddp), proximal momentary pointing (pmp) and proximal dynamic-sustained pointing combined with a gaze (head and eye direction) cue (pdg). During a distal dynamic-sustained pointing, experimenter 1 stood at 2 m from each boxes, looked at the subject and pointed to the baited box, keeping her arm held in the pointing position during the whole trial until the subject made their choice. The distance between the tip of the finger and the baited box was about 1 m.

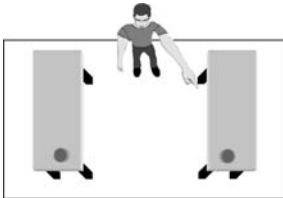
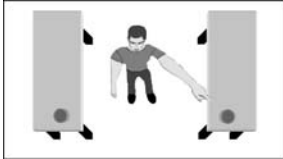
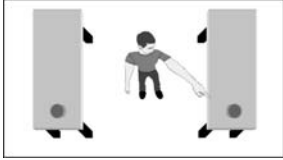
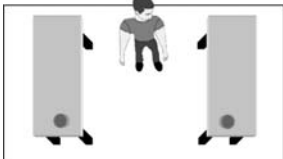

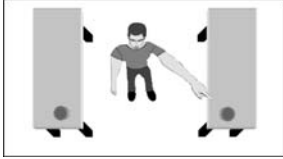
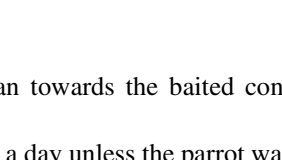
The proximal momentary pointing trials involved the same gesture as distal dynamic pointing except that the distance between the tip of the finger and the baited box was reduced to 10–20 cm (experimenter 1 remained equidistant between the boxes, about 1 m, but moved forwards towards the front of the tables, so that the pointing cue was in closer proximity). During a proximal dynamic-sustained pointing with gazing trial, the experimenter stood at 1 m from each boxes, looked at the target (baited box) and kept her arm held in the pointing position during the whole trial until the subject chose. The distance between the tip of the finger and the baited box was approximately 10–20 cm.

Thirty trials (usually 10 trials a day unless the parrot was not motivated enough) were done for each pointing type (90 trials in all) in a pseudorandom order with a given pointing type not presented more than two times successively. The position of the baited object was pseudorandomized as before.

Test 3: gazing versus pointing

As two of the parrots (see “[Results](#)”) were successful in using the proximal dynamic-sustained point with gazing cue, three and half months later, we conducted a third test to investigate which cue (gazing and/or pointing) was the more salient. We first checked baseline performances for each subject during training sessions (as in the training protocol). We started the test sessions when the parrots reached a criterion of 90% correct responses across two consecutive sessions. Once this criterion was met, we tested three types of cues in random order: distal gazing cue (dgc),

Table 1 Cue characteristics

Cue type	Orientation of the head and eyes	Distance between the hand or head and the baited box	Duration of cueing	Schematic representations
Distal momentary pointing	Toward subject	About 100 cm (finger tip to box)	About 2 s	
Distal dynamic-sustained pointing	Toward subject	About 100 cm (finger tip to box)	Until the choice of the parrot	
Proximal momentary pointing	Toward subject	About 10 cm (finger tip to box)	About 2 s	
Proximal dynamic-sustained pointing with gazing	Toward baited box	About 10 cm (finger tip to box)	Until the choice of the parrot	
Distal gaze	Toward baited box	About 200 cm (head to box)	Until the choice of the parrot	
Proximal gaze	Toward baited box	About 100 cm (head to box)	Until the choice of the parrot	
Proximal dynamic-sustained pointing without gazing	Toward subject	About 10 cm (finger tip to box)	Until the choice of the parrot	

proximal gazing cue (pgc) and proximal dynamic-sustained pointing (pdp).

During a distal gazing cue and a proximal gazing cue trial, experimenter 1 stood 2 and 1 m away from each box, respectively, and gazed at the baited box (head and eyes oriented towards the target) until the subject made their choice. A proximal dynamic-sustained pointing trial was identical to a proximal dynamic-sustained pointing with gazing trial except that during pointing, the experimenter

looked at the subject rather than towards the baited container.

Thirty trials (usually 10 trials a day unless the parrot was not motivated enough) were done for each pointing type (90 trials in all) in a pseudorandom order with a given pointing type not presented more than two times successively. The position of the baited object was pseudorandomized as described before. We also conducted a final testing session of ten trials, in which the parrot was not

cued at all, to check that the birds did not learn to use any cues to find the hidden food, other than those tested.

Statistical analysis

During training and test sessions, we recorded the percent of correct responses and we compared the parrots' performances with chance using a binomial test. To examine learning effects, the performances of each parrot during the first half of all sessions were compared with those during the second half of all sessions with a chi-square test.

Ethical note

The birds were food-deprived for 2 h before training and test sessions. The calorific content of the seeds they received during the test compensated for any effect of the food deprivation upon daily intake. Moreover, we gave them supplementary food (fruits) after each session. We also ensured that they did not lose weight by weighing them weekly; during the test period, Shango weighed 441.50 g (SEM = ± 2.06 g), Léo 428.25 g (SEM = ± 5.95 g) and Zoé 414.75 g (SEM = ± 2.29).

Between each trial, the parrots were placed in a small holding cage. They are fully habituated to this procedure and it is not stressful for the parrots; it is used almost every day to transport the parrots from their aviary to the other room as part of the daily routine.

Moreover, during training and test trials, the parrots had to fly to a table (see "Training" under "Materials and methods"). In this way, the subjects' participation was voluntary: they also could fly to a perch in another part of the aviary or stay on the start table. When this occurred, we put the subject back in the holding cage to start the trial again, but we ended the session if the subject did not respond or flew to another place on two consecutive trials.

Results

Training

Zoé reached the criterion in five sessions, Léo in six sessions and Shango in four sessions.

Tests 1 and 2

Figure 1 presents the results obtained for each parrot for each kind of pointing in tests 1 and 2. None of the three parrots chose the rewarded box significantly above chance when it was indicated with a distal cue (either momentary or dynamic). Zoé responded correctly on 35.00% of trials (binomial test: $z = 1.12$, $P = 0.131$) with distal momentary

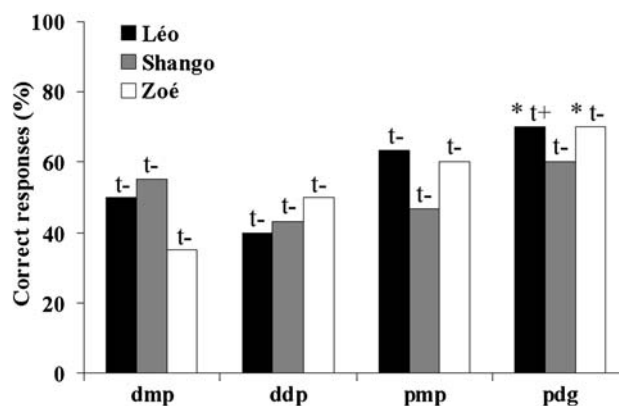


Fig. 1 Percentage of correct responses according to the type of cues in tests 1 and 2. *Binomial test, $P < 0.05$ — t^- no significant training effect (χ^2 , ns), t^+ training effect (χ^2 , $P < 0.05$). *dmp* distal momentary pointing, *ddp* distal dynamic-sustained pointing, *pmp* proximal momentary pointing; *pdg* proximal dynamic-sustained pointing with gaze

pointing and 50.00% (binomial test: $z = 0$, $P = 0.5$) with distal dynamic-sustained pointing, Shango was correct on 55.00% (binomial test: $z = 0.22$, $P = 0.413$) and 43.33% (binomial test: $z = 0.54$, $P = 0.295$), respectively, and Léo 50% (binomial test: $z = 0$, $P = 0.5$) and 40% (binomial test: $z = 0.91$, $P = 0.181$), respectively. Chi-square tests on patterns of responses during the first half of sessions compared to the last half of sessions did not reveal a significant difference for any of the parrots: Zoé, distal momentary pointing ($\chi_1^2 = 0.21$, $P = 0.639$), distal dynamic-sustained pointing ($\chi_1^2 = 0.13$, $P = 0.715$); Shango, distal momentary pointing ($\chi_1^2 = 0.20$, $P = 0.653$), distal dynamic-sustained pointing ($\chi_1^2 = 3.39$, $P = 0.065$); Léo, distal momentary pointing ($\chi_1^2 = 0.8$, $P = 0.371$), distal dynamic-sustained pointing ($\chi_1^2 = 0$, $P = 1$). That is, the performance of the parrots did not improve (or decrease) across sessions indicating that there was no training effect.

The parrots were not significantly above chance levels when the rewarded box was proximally and momentarily pointed to: Zoé was correct on 60.00% of trials (binomial test: $z = 0.91$, $P = 0.181$), Shango 46.67% (binomial test: $z = 0.18$, $P = 0.429$) and Léo 63.33% (binomial test: $z = 1.27$, $P = 0.102$). There was no evidence of any training effect (chi-square tests; Zoé: $\chi_1^2 = 0$, $P = 1$; Shango: $\chi_1^2 = 0.53$, $P = 0.464$; Léo: $\chi_1^2 = 1.29$, $P = 0.256$).

When the experimenter proximally and dynamically pointed to and gazed at the target, both Zoé and Léo made correct responses on 70.00% of trials (binomial test: $z = 2.008$, $P = 0.023$). A chi-square test revealed a significant training effect for Léo ($\chi_1^2 = 3.96$, $P = 0.046$) but not for Zoé ($\chi_1^2 = 0.16$, $P = 0.690$). Shango responded at chance levels: 60.00% (binomial test: $z = 0.91$, $P = 0.181$), and without modification of his responses across trials (chi-square test, $\chi_1^2 = 0$, $P = 1$). Léo and Shango were wrong

for their first trial. Zoé correctly chose the rewarded box on the first trial (and four times on the five first trials).

To examine whether the parrots need both of the cues or if one were necessary and sufficient, we conducted a third test in which we separated gazing and pointing cues.

Test 3

Léo reached the criterion to start test trials after two training sessions, and Zoé and Shango after four sessions.

The performance levels of each parrot in test 3 are presented in Fig. 2. None of the three parrots reliably chose the rewarded box when cued only with a distal gaze: Zoé was correct on 50.00% of trials [binomial test: $z = 0$, $P = 0.5$; no training effect (chi-square test): $\chi_1^2 = 1.2$, $P = 0.273$], Shango 46.67% [binomial test: $z = 0.18$, $P = 0.429$; no training effect (chi-square test): $\chi_1^2 = 0$, $P = 1$] and Léo 63.33% [binomial test: $z = 1.28$, $P = 0.1$; no training effect (chi-square test): $\chi_1^2 = 3.59$, $P = 0.058$].

However, Shango chose the baited box when cued with a proximal gaze at above-chance levels [70%, binomial test: $z = 2.01$, $P = 0.022$; training effect (chi-square test): $\chi_1^2 = 3.96$, $P = 0.046$], but the two others did not, Zoé: 60% [binomial test: $z = 0.91$, $P = 0.181$; no training effect (chi-square test): $\chi_1^2 = 2.22$, $P = 0.136$] and Léo: 50% [binomial test: $z = 0$, $P = 1$; no training effect (chi-square test): $\chi_1^2 = 0.13$, $P = 0.715$].

The three parrots reliably chose the baited box when it was indicated with a proximal dynamic-sustained pointing, Zoé: 80% [binomial test: $z = 3.10$, $P = 0.001$; no training effect (chi-square test): $\chi_1^2 = 0.83$, $P = 0.361$], Shango: 80% [binomial test: $z = 3.10$, $P = 0.001$; no training effect (chi-square test): $\chi_1^2 = 3.33$, $P = 0.068$], Léo: 66.67%

[binomial test: $z = 1.64$, $P = 0.049$; no training effect (chi-square test): $\chi_1^2 = 2.4$, $P = 0.121$].

Control

During the last testing phase in which no one cue was given to the subjects, the performances of Léo, Shango and Zoé were at chance level: Léo was correct on 50.00% of trials (binomial test: $z = 0$, $P = 0.5$), Shango at 60.00% (binomial test: $z = 0.31$, $P = 0.378$) and Zoé at 40.00% (binomial test: $z = 0.31$, $P = 0.378$).

Discussion

None of the three parrots were able to use any of the distal or momentary cues, whether pointing or gazing. Zoé and Léo used the proximal dynamic-sustained point with gazing cue appropriately to locate hidden food. This ability appears to have been spontaneous for Zoé, compared to Léo, who seems to have learned to use the cue during testing. Shango did not make use of the proximal dynamic-sustained point with gazing cue. Three months later, however, Shango was able to locate the baited bowl when it was cued with either a proximal dynamic-sustained pointing gesture or with a proximal gaze cue. For this latter cue, Shango appears to have learned to use the gaze during testing. Léo and Zoé were not able to find the baited bowl when it was cued with a gaze, whether proximal or distal, but they both used proximal dynamic-sustained pointing appropriately. Of course, as we tested only three birds and as we found considerable interindividual variability, we cannot generalize to the species as a whole, but these results may reveal some of the species abilities.

Concerning the pointing gestures investigated in the present study, the parrots were only able to use the proximal dynamic cue. However, the fact that they use this pointing gesture to locate hidden food does not necessarily signify that they understand the referential value of the gesture. Interestingly, Shango was not able to comprehend this cue when accompanied with a gaze, but he was able to comprehend it when presented without a gaze, 4 months later. It seems unlikely that he learned to comprehend the cue between the two tests. Two explanations could be proposed. First, even though the chi-square test did not reveal significant training effect between the first half and the second half of the test, we cannot exclude that Shango did learn the cue during testing. The second explanation (which does not exclude the other one) is that Shango may have learned to be more attentive to the cues given by the experimenter. These explanations also apply to Léo's ability to comprehend the same cue (with or without gaze), but they are probably not applicable to Zoé, who seems to have

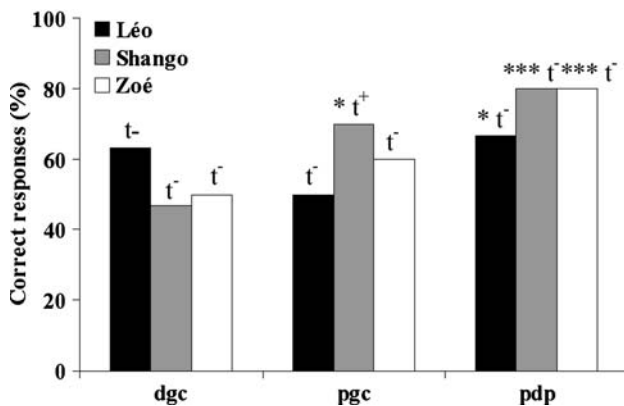


Fig. 2 Percentage of correct responses according to the type of cues presented in test 3. * ***Binomial test, $P < 0.05$ and $P < 0.001$ — t^- and t^+ no significant training effect (χ^2 , ns) and training effect (χ^2 , $P < 0.05$), respectively. *dgc* distal gazing cue, *pgc* proximal gazing cue, *pdp* proximal dynamic-sustained pointing

comprehended this cue spontaneously (moreover, she was correct on the first trial of the proximal static pointing cue, whereas Léo and Shango were not).

In addition, the experimenter's proximity had probably influenced the parrots' responses. When making the proximal dynamic pointing cue, the tip of the finger and the baited bowl are separated by 10–20 cm, and the cue was maintained until the subject made their choice. When pointing was presented momentarily and/or distally, none of the three parrots were able to comprehend the pointing cue. Thus, there is probably a component of local enhancement or stimulus enhancement for the proximal dynamic pointing, as the subject's attention may be directed by the movement produced just near the baited box. Even though dogs are able to spontaneously use some pointing cues to find a reward (Miklósi et al. 1998), it appears that they choose the bowl nearest to the experimenter (Hare and Tomasello 1999), as wolves (Miklósi et al. 2003) and chimpanzees (Itakura et al. 1999) do. It is also clear that the dogs are socialized with many humans in various contexts and that their performances can be based on their previous experience of interactions with humans (Miklósi et al. 1998), contrary to our parrots, which are only socialized with a few people in the laboratory. However, as experimenter 1 is the parrots' main caretaker and feeds them daily, they could have learned to associate her hands with food (even though we were careful not to use pointing gestures in everyday interactions with the parrots). The parrots could have also preferred the box closer to the hand in order to be closer to the experimenter. Our parrots often spontaneously seek out physical contact with the experimenter, and also seek protection through proximity to the experimenter when something novel occurs in their aviary (personal observation). Two of the three parrots also showed some evidence of learning during the test, suggesting that they may have formed a simple association between the hand and the reward.

This study suggests that Gray parrots do not spontaneously comprehend the experimenter's gaze cue to find a baited box; Shango seemed to learn the association between the head/eyes orientation across testing rather than understanding the cue as a communicative signal. Dogs also showed some difficulties to spontaneously comprehend glancing as a communicative cue: it appears that they improved their performances across test trials (Miklósi et al. 1998), as Shango did. However, our results do not preclude the possibility that parrots could be able to follow and comprehend human gaze in other contexts, especially in competitive situations; for example, they might readily avoid certain behaviors or responses when a human looks at them, such as bee-eaters have been shown to do (Watve et al. 2002).

We also believe that our birds might be too young to perform well on this sort of task. Ravens for example

geometrically follow the human gaze around a barrier from 6 months of age, but not before (Bugnyar et al. 2004). Gray parrots reach maturity at about 5 years and can live up to 50–60 years in captivity (Pratx 2004). As a result, their ability to understand cues such as gazing or pointing could improve over the next few years.

The object-choice paradigm may not be the best means of assessing understanding of gaze in nonhumans. Human children have trouble using gazes to find hidden food before the age of two, although there is some evidence of gaze use as early as 14 months (Behne et al. 2005; Itakura and Tanaka 1998). Children spontaneously follow the human gaze during the first months (Farroni et al. 2003). Similar observations have been reported in some monkeys and apes (Vick and Anderson 2003). Thus, perhaps gray parrots can spontaneously follow human gaze in other paradigms. In addition, there is some indirect evidence of sensitivity to human gaze in parrots; African gray parrots fail to referentially learn English labels in the absence of joint attention, i.e., shared visual attention between trainee and trainer (Pepperberg and McLaughlin 1996). It is interesting to note that Shango's ability to comprehend the proximal dynamic cues occurred around the same time as he started to referentially imitate his first human labels. Zoé comprehended human labels in the correct context before the experiment and she was the only one to spontaneously understand the proximal dynamic-sustained pointing. However, Léo very rarely pronounced any human labels, and never referentially. He was able to comprehend the proximal dynamic-sustained pointing but only after some training. Thus, joint attention can be an important feature to understand, or at least follow, human pointing and also to learn the referential use of labels. Joint attention also appears to be an important component in the language acquisition in human children, and especially for acquiring referential value of labels (Baldwin 1991; Dominey and Dodane 2004). Thus, abilities for joint attention, comprehension of pointing gestures and use of referential labels could be correlated in nonhumans like in humans, as this study suggests with parrots.

In summary, of the three African gray parrots tested, two were able to follow a salient pointing gesture and one was also able to comprehend human gaze (head direction) to locate hidden food with minimal training (20–30 trials for each type of gesture). However, they were not able to comprehend momentary pointing nor distal pointing and gazing cues. Some variables, such as the proximity of the experimenter to the objects, the age of the subjects, the importance of joint attention and the referential use of labels, require further investigation, but to our knowledge, this is the first demonstration in birds of an ability to make use of experimenter-given pointing cues in an object-choice task.

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