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SHORT COMMUNICATION

A Bottlenose Dolphin's (*Tursiops truncatus)* Responses to Its Mirror Image: Further Analysis

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In the present study we provide more specific analyses of the responses of a subadult bottlenose dolphin (*Tursiops truncatus*) to a mirror from an earlier study. An ethogram was constructed in order to classify specific behaviors as contingency checking, social, and other. This ethogram was used to develop a continuous record of behaviors of the dolphin at a mirror and the durations of those behaviors over nine test sessions dispersed across nine days. The subject spent an increasing proportion of time engaged in contingency checking behaviors, such as repetitive head and body movements, over the nine sessions, a very small proportion of time engaged in social behaviors, and another larger proportion of time engaged in behaviors that were unusual but not strictly classifiable as contingency checking or social. These other behaviors included head orientations and circling at the mirror. These findings will add to the ongoing effort to describe and compare mirror responses in cetaceans and primates.

Recent evidence shows that bottlenose dolphins (*Tursiops truncatus*) possess the capacity for mirror self recognition, or MSR (Reiss & Marino, 2001). The bottlenose dolphin has long been considered a likely candidate for MSR due to its high level of encephalization (Marino, 1998), and complex cognitive (Herman, 1987; Reiss et al., 1997; Schusterman et al.,1986) and social abilities (Marino, 2002).

Until recently, the great apes (i.e., chimpanzees, *Pan troglodytes* and *P. paniscus;* orangutans, *Pongo pygmaeus*; and one language trained gorilla, *Gorilla gorilla*), were the only nonhuman species to demonstrate MSR (Amsterdam, 1972; Gallup, 1970; Lethmate & Ducker, 1972; Miles, 1994; Patterson & Cohn, 1994; Povinelli et al., 1997; Povinelli et al., 1993; Walraven et al., 1995;). No monkeys appear to have this ability (Anderson, 1983; Anderson & Roeder, 1989; Bayart & Anderson, 1985; Gallup et al., 1980; Hyatt, 1998; Shaffer & Renner, 2000; Suarez & Gallup, 1986).

MSR does not reliably emerge in humans until approximately 18-24 months of age (Amsterdam, 1972). Normal children initially show social behavior at a mirror and then advance to contingency checking (CC) and self directed (SD) behaviors (de Veer & van den Bos, 1999). CC behavior typically involves an unusual repetitive body movement while visually oriented to the mirror. In humans and great apes, CC behaviors usually take the form of repetitive head or hand motions (Povinelli et al., 1993). In dolphins, CC behaviors may include head or body cock-

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ing, repetitive horizontal and vertical head movements, and head circling (Marino et al., 1994; Reiss & Marino, 2001). SD behaviors occur when a subject uses a mirror to investigate parts of its body that would not be visible without the mirror. An example of SD behavior in humans or great apes would be using one's mirror image to view one's genitals (Gallup, 1970). In dolphins, examples of SD behaviors may include unusual neck stretching and body flexing (Marino et al., 1994; Reiss & Marino, 2001)

When confronted with a mirror for the first time, chimpanzees initially respond socially, displaying a variety of aggressive as well as affiliative social behaviors to their reflection. These reactions often diminish as the animal begins to show CC and SD behaviors (Gallup, 1970). The definitive test of MSR is the mark test. After being anesthetized and marked with an odorless nontactile dye, self recognizing chimpanzees confronted with a mirror respond by focusing their behaviors on the newly marked area of their body. Importantly, the subject does not respond in this way under any of the complementary control conditions in which there is either no mirror present or no actual mark.

Asian elephants (*Elephas maximus;* Povinelli, 1989) and all monkey species tested (e.g., Anderson, 1986; Itakura, 1987) exhibit mirror guided behavior (i.e., the ability to use a mirror to guide a part of one's body towards hidden food). An African Grey parrot (*Psittacus erithacus*) exhibited mirror mediated object discrimination (Pepperberg et al., 1995). But although these species can process mirror information, there is no compelling evidence that they use a mirror to investigate marked parts of their body or show CC and/or SD responses.

Early studies of mirror responses in dolphins demonstrated only suggestive evidence of MSR (Marino et al., 1994; Marten & Psarakos, 1994). However, recently Reiss and Marino (2001) provided the first conclusive evidence of MSR in bottlenose dolphins by employing a protocol adapted from primate MSR studies to show that two bottlenose dolphins were capable of using a mirror to investigate marked parts of their body. There is inconclusive evidence for MSR in killer whales (*Orcinus orca*) and false killer whales (*Pseudorca crassidens;* Delfour & Marten, 2001).

The evidence for dolphin MSR contrasts with the previously held view that MSR is confined to humans and great apes. Dolphins and primates have been on divergent evolutionary trajectories for 90-million years in which both adapted to very different physical environments. Moreover, the trends that characterize the elaboration of the brains of primates and cetaceans are very different (Glezer et al., 1988).

The present study is part of a larger effort that began with Marino et al. (1994) to address the following question: How did two phylogenetically divergent mammal groups–primates and cetaceans-converge upon the same extremely rare capacity for self recognition? Although a few studies have provided quantitative and qualitative descriptions of dolphin responses to mirrors (Marino et al., 1994; Marten & Psarakos, 1994; Reiss & Marino 2001), further descriptions with additional detail are needed. Furthermore, the positive results of Reiss and Marino (2001) suggest that there is much to be gained by revisiting and further analyzing the responses of all of the dolphins that were confronted by a mirror in previous studies. In the present study we reexamine the behavior of one of the subjects in Marino et al. (1994).

Method

Subject

The subject of this study is a captive male bottlenose dolphin (*T. truncatus*) named Pan, who was seven years old at the time of testing. Pan was captive born and raised with his half sibling, Delphi, at Marine World USA in Vallejo, California. Pan appeared to be the more dominant of the pair and, overall, showed more assertive responses to the mirror throughout testing than Delphi. For these reasons it is more likely that many of Delphi's responses to the mirror were dependent upon Pan's responses. Therefore, we chose Pan as our subject for the present study,

Pan and Delphi were the subjects of a previous study of MSR by Marino et al. (1994). In that study, the behavior of the two dolphins in the presence and absence of a mirror was described but not detailed as much as in the present study. It should also be noted that in the 1994 study during an informal, but nonconclusive mark test, Pan exhibited behavior suggesting he recognized himself in the mirror. But the test did not provide conclusive evidence of passing or failing the mark test. The possibility that Pan did recognize himself in the mirror in the earlier study makes a detailed reanalysis of his behaviors in the present study all the more intriguing.

Apparatus and Procedure

A behavioral ethogram was compiled from the literature and from previous studies on Pan and Delphi (conducted by one of the authors, DR). During the development of the ethogram, categories of behavior were initially divided into subsections specifying "Modifiers," "Underwater Stationing or Swim," and "Underwater Behaviors that Occur During Stationing and Visual Orientation to Mirror." The list of behaviors was then modified for clarity and detail as well as for accuracy of coding. Redundant classifications were collapsed.

Pan and Delphi were housed and tested in a circular pool that is 18.3 m in diameter and 5.5 m deep. The pool is connected to an identical pool by a channel 6.1 m long and 3.7 m deep. The dolphins were exposed to a 0.9 x 1.5 m underwater one-way Plexiglass mirror placed at the opening of the channel in the pool. No other mirrors or underwater windows were available to the dolphins prior to or during the study. Observations during the original study were recorded using an underwater Sony Video 8 Handycam CCD-M8u and an above water Sony Trinitron video camera as well as a Navy Sonabuoy hydrophone that were positioned on the transparent side of the mirror in the channel.

The VHS VCR tapes spanned nine days of recording with one session per day. In the present study, behaviors were analyzed while observing the underwater video footage obtained during the Marino et al. study. Sessions included conditions in which the mirror was exposed as well as control conditions in which the mirror was covered or not present. In the present study we focused exclusively on describing Pan's behavior at the mirror only in those sessions in which the mirror was exposed because Pan's behavior under control conditions has been described previously (Marino et al., 1994) and our focal interest in the present study is in the morphology of the behaviors at the mirror. The duration of these sessions was between 30 and 120 min per day, with a modal duration of 90 min across the nine days.

A continuous record of Pan's behavior at the mirror was created for the total duration of each session across the nine days using the coded behaviors from the ethogram. On each data sheet the following information was continuously recorded: behavioral code, onset of behavior (from a counter on the videotape), and any additional comments qualifying the behavior. These data were entered into an Excel spreadsheet. Because a continuous record of Pan's behavior was available, duration of each behavior (or group of behaviors) was obtainable by subtracting the beginning of one coded behavior from that of the next coded behavior. Additionally, a higher order classification of behavior was employed. Behaviors were designated as either Contingency Checking (CC), Social (S), or Other (O). CC behaviors were defined as two or more repetitions of a bodily movement while visually oriented to the mirror, or a posture or movement that alternately hid and exposed a body part to the mirror. CC behaviors included horizontal and vertical head movements, head dips below the frame of the mirror, head circling, pectoral fin lifts, neck stretches, body flexes, other horizontal and vertical body movements, and body rolls. Also included as CC behaviors were actions that involved directly bringing an object (e.g., a toy), to the mirror that did not occur under any other circumstances. S behaviors were defined as clear-cut affiliative or aggressive behaviors at the mirror and included open mouth, jaw clap, and tail kerpluncks. In general, tail kerpluncks are frequently seen

during affiliative or invitational playful chase interactions among dolphins. Jaw claps and open mouth behaviors are typically observed during aggressive encounters with other dolphins. The O category included ambiguous behaviors that are not clearly S or CC but may nonetheless be of interest due to their prevalence or unusual nature. These categorizations are similar to those used in a comprehensive study of chimpanzee responses to mirrors (Povinelli et al., 1993). Several O behaviors were collapsed into the following categories: Stationing (stationing at mirror including stationing perpendicularly, stationing with right or left side of body to mirror, stationing while ventrally oriented to mirror, and brief orients during swim bys) or Swims (fast or slow swims around the pool but not at the mirror). Specific O behaviors included a peculiar body movement called a Quiver Swim, back ups and advances at the mirror, circling in front of the mirror, corkscrew movements in front of the mirror (typically when stopping to station at mirror), various head positions (but not movements) such as right and left orients to the mirror, contact with the mirror with some part of the body such as the pectoral fin, bubble production at mirror (including bubble bursts, bubble streams, and bubble play), and sexual behavior at the mirror directed towards the other dolphin in the pool. It should also be noted that many of the behaviors categorized as O could arguably be classified as CC. However, we elected to be conservative in our interpretation of Pan's behaviors when forming these classifications.

Coding reliability was handled by requiring that two coders (DS and LM) independently score the same 1-h session of tape. One coder, LM, was considered the standard to be achieved by DS. The criterion for full agreement was that the sequence of specific behaviors coded by DS and LM had to be the same. The duration of each behavior could differ slightly (by a few seconds). Afterwards, all behavioral sequences that differed between DS and LM were reviewed and agreed upon. Actual scoring, which was done by DS, began only when both DS and LM were able to obtain full agreement on behavioral scoring for that one hour session.

Results

Proportion of Time Spent at and away from Mirror

Overall, Pan spent more of his time during the nine day test period in front of the mirror (54%) than away from the mirror (46%). Time spent at the mirror was divided into stationing (50% of total time) and circling in the vicinity of the mirror (4% of total time). (The more specific behaviors described below occurred during the stationing bouts.) Time spent away from the mirror was divided into fast swimming around the tank (2% of total time), and slower swimming around the tank (44% of total time).

Pan spent more time away from the mirror than at the mirror during the first six sessions. However, this pattern clearly changed on day seven when he began to spend more time at the mirror than away from the mirror and continued to do so during the last three sessions. These findings are consistent with earlier observations of Pan's behavior (Marino et al., 1994).

Figure 1 displays the percentage of time in each session spent on CC and S behaviors. In order to highlight the pattern of CC and S behaviors (given that these categories are more diagnostic of whether or not the subject recognizes itself in a mirror than O behaviors) without scaling for the high proportion of O behaviors, O behaviors have been omitted from Figure 1. Figure 1 shows that S behaviors remain at an extremely low frequency throughout the study. Additionally, over time the proportion of each session that Pan spent engaged in CC behaviors increased as the proportion of O behaviors decreased.

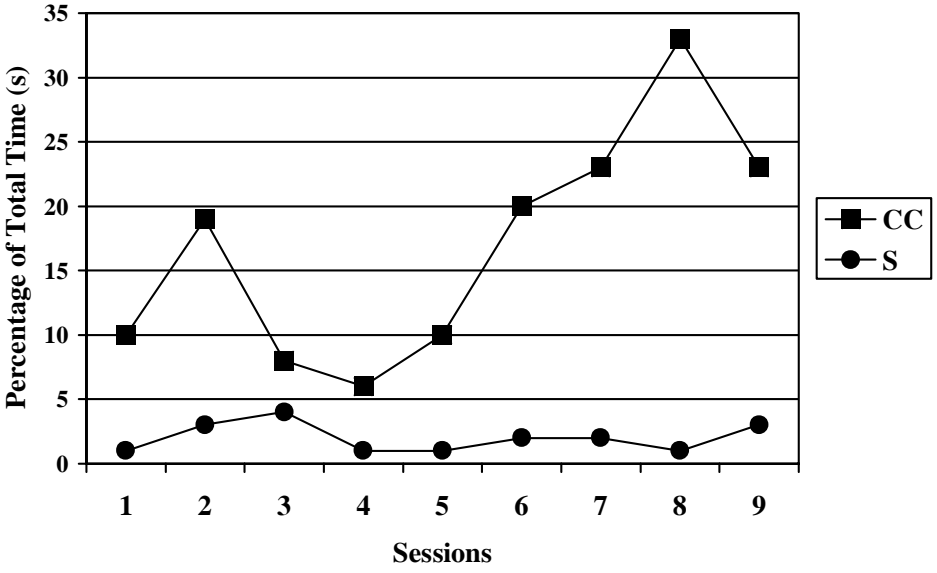

Figure 1. Proportion of time in each session Pan spent on CC and S behaviors.

Contingency Checking Behaviors

Figure 2 compares the total duration of the most prevalent CC behaviors across the sessions. The most prevalent CC behaviors were DIP (head dips below mirror), HMV (vertical head movements), HMH (horizontal head movements), and HBC (head and/or body cocking). Many of these behaviors would occur together in rapid succession during a given bout of behavior in front of the mirror. DIP shows a steady increase across sessions, as do HMV and HBC. HMH increases across the sessions as well, but moderately. Those behaviors that occurred for less than 120 s during any session are omitted from Figure 2. The omitted behaviors include body rolls to left and right, carrying toys to the mirror (which occurred during sessions 2,6,7,8, and 9), neck stretches, body flexes, and left and right pectoral lifts. Besides the floating toys provided for the dolphins, Pan would improvise by pulling on a tarp that dangled just above the mirror at the water's surface.

Social Behaviors

Pan displayed extremely few social behaviors at the mirror compared with CC and O behaviors. Open-mouthed behavior was the most prevalent social behavior with a total duration of 749 s across the entire nine-day test period. Tail kerplunks and jaw claps occurred only for a total of 175 s and 29 s across the entire nine day test period, respectively.

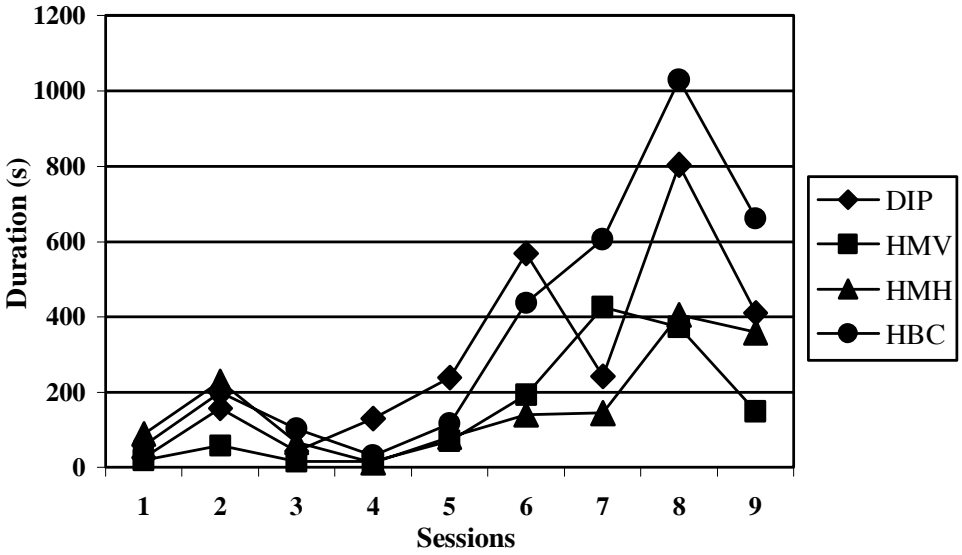

Figure 2. Total duration of the most prevalent CC behaviors across the sessions.

Other Behaviors

The most prevalent O behaviors were circling at the mirror, stationing, and head orienting to the right and/or left, and the head down position. Circling behavior occurred at a high level throughout the nine sessions. Consistent with the pattern of increasing duration at the mirror Stationing behavior increased steadily over the nine sessions. Head posturing increased substantially after session 5. The rest of the O behaviors occurred at a low level throughout the duration of the study although not during every session. Sexual behaviors (again, between Pan and Delphi, not Pan and the mirror image) increased dramatically during the last session.

Discussion

The present study provides a qualitative and quantitative description of the behavior of one subadult male bottlenose dolphin, Pan, at a mirror. It should be noted, however, that this study is limited by its focus on a single subject during a restricted time period. The time period covered by the present study (i.e., from the initial phase of mirror introduction to several days beyond that time), is similar to that in primate studies, but it is always possible that long-term changes in Pan's behavior would have occurred had the study continued.

The present analysis revealed that the pattern of time spent at and away from the mirror by Pan is consistent with earlier findings (Marino et al., 1994). These findings, however, are contrary to those reported in Gallup (1970) and other chimpanzee studies showing a decrease in amount of time at mirror over sessions.

Social behaviors remained at extremely low durations throughout the sessions. This may have been due, in part, to the relatively few behaviors from the ethogram that could be definitively designated as social (i.e., only three). CC be-

haviors showed a steady increase across the sessions, and the durations of O behaviors remained consistently high. Gallup (1970) and Povinelli et al., (1993) showed that, in chimpanzees, social responsiveness declines and contingency checking increases over time of exposure to the mirror. Pan's behavior is consistent with these findings for CC behaviors, but not for S behaviors. However, this may be due to the fact that the baseline frequency of social behaviors was extremely low at the onset.

The analysis of the S behaviors reveals that OM was the most prevalent social behavior. Notably, OM is also the most ambiguous of the social behaviors and has been construed as self directed in other studies (Marten & Psarakos, 1994). The pattern of some of the categorized O behaviors (i.e., stationing), was consistent with the pattern of increased duration at the mirror displayed by Pan across the nine sessions. Interestingly, head posturing increased substantially after session five. Head posturing behaviors could not be unequivocally categorized as CC behaviors but they are consistent with CC behaviors and could, using a more liberal criterion, be considered CC behaviors.

In conclusion, this paper presents further analysis of a dolphin's response to a mirror from the original study (Marino et al., 1994). The findings show that some patterns of behavior in the dolphin study are similar to, but some are different from the patterns of response typically reported for chimpanzees. This analysis can serve as the basis for similar analyses with other dolphin subjects of mirror studies. Furthermore, future analyses of dolphin responses to mirrors will eventually be compared to similar work with primates and other cetaceans to develop a comparative ethographic description of mirror responses in primates and dolphins.

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