

Conclusions and Possibilities of New Frameworks and Techniques for Research on Marine Mammal Cognition

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We have tried, both in the cognitive workshop and in this special issue, to review the rich literature on experimental laboratory work and present new research frameworks for consideration. For years, the laboratories of Drs. Louis Herman, Ron Schusterman, Herb Roitblatt, Paul Nachtigall, and others, paved the way—and wrote the book—on experimental marine mammal cognition. Herein, our contributors have presented new frameworks and techniques that might continue and advance this work, enabling us to address cognitive questions both in the laboratory and in natural observational settings. In the latter especially, distributed cognition, by its definition in terms of measurable, observable phenomena (vs inferred mental states), makes new data available in such settings. Data from observational settings may be critical in this time period when the cognitive laboratories of the past no longer exist or no longer conduct experimental cognitive work. By taking a look at other available settings and partnerships where observational work can occur, in both captivity and in the wild, we hope to open new avenues of research beyond the laboratory setting.

As a way of summarizing the themes of the workshop presentations, areas of discussions, and contributions of this special issue, we review some main points of concern that emerged in this process that we believe are important to continue exploration of marine mammal cognition:

1. *Field, Observation, and Laboratory Work*—Most researchers agree that field and laboratory work can, and should, be complementary. Some questions such as the range and limits of sensory abilities may best be asked and answered with experimental procedures in the laboratory. Other questions, such as how animals use their cognitive capacities in the real world, may best be answered in the field or in “observable” captive situations. Both types of research can inform the other and could be used synergistically.
2. *Development Issues*—The complexity of social and other adaptive behaviors in marine mammals indicates that it would be productive to track the development of these behaviors. Although there is still a strong debate as to whether the higher cognitive skills that emerge in these contexts are innate, learned, or to what extent they are some combination of the two, more data on their ontogeny can only help us to better understand their origins and functions.
3. *Individual Differences*—The range of individual strategies and behavioral tendencies of primates and marine mammals indicates that we should be developing measures of tendencies and personalities (as is beginning to be done for a variety of taxa). It is partially this complexity that makes a rich cognitive world in complex societies both necessary and possible.
4. *Statistics and Normalization*—This issue is especially critical given #3 above. Most statistics guide us to look for population parameters, normal trends, average performance, etc., and downplay individual variation. Many of us in the behavioral field have struggled with this concept since it does, by its very nature, dilute or obscure the things that we are most interested in studying such as variation in cognitive or behavioral strategies or pivotal individuals or events. We look to alternative, nonparametric statistical tests to illuminate our data, such as Chi-square tests, Lag Sequential models, or Markov chain analysis, which begin to look at the distribution, ordering, timing, or patterning of behaviors. In addition, we recognize that low frequency events, not susceptible to any such analysis, can nonetheless be extremely telling and important in the life history of an individual or group. One-time life events—such as the displacement of an alpha male,

the innovation of a foraging technique, an exposure to a predation trauma, etc.—may be critical to an accurate explanation of changes in social structure, distribution, or behavior. Some of the tools mentioned in this volume may point to analysis techniques that would complement the traditional scientific approaches and enable us to address the full richness of the complex phenomena that we observe.

5. *Temporal Issues*—Our abilities to analyze the behavior of fast-moving animals may require us to relook at our technology. Slow-motion or fast-motion analysis of video, for example, is required for micro-ethological measures. Concomitantly, there may be a danger of getting too micro, or seeing patterns that may not be there, or are merely mechanical in nature. Suggestions that arose in our discussions at the workshop include (1) repeatedly switch between slow-motion and real-time analysis; (2) use fast-motion to show larger patterns without getting distracted by potentially unimportant details; (3) remember, as well, that slow- or fast-motion analysis can hide real-time dynamic properties between individuals; and (4) patterns we do see still have to be tested for relevance to the animals.
6. *Sensory Umwelt, Behavioral Context, and Ecological Validity*—As is also pointed out in this volume, much of the traditional experimental work has involved isolating subjects from their normal sensory or social milieu. If indeed social relationships and rich behavioral contexts provide the necessary setting for cognitive skills to emerge, then providing new research contexts that incorporate equally rich behavioral environments may yield exciting results. This was brought up in several talks (e.g., Russon, Forster, Johnson, Herzing, Deecke) that focused on *in situ* research. In the discussion, Diana Reiss and Stan Kuczaj also noted that dolphins, unlike the more typical laboratory animals, such as pigeons and rats, are often best trained not just using extrinsic (e.g., food) rewards but intrinsic, self-reinforcing ones as well. Thus, for example, there is much to be learned by providing opportunities for dolphins to display and follow their own motivations. Also in this volume, Johnson and D'Arcy point out that any experimental setting where researchers interact with their subjects is a social interaction. Similarly, Thompson's work shows that the presence of multiple

subjects influences performance. All of the above suggest that new work should keep in mind the importance of ecologically and socially valid contexts, whatever their research design.

7. *Cross-Taxa Comparisons*—Clearly, both the presenters and participants in this workshop agreed on the value of comparing the cognition of marine mammals and primates. Nonetheless, we also recognize that such comparisons are fraught with difficulties. Which comparisons are valid? One issue concerns the sensory/perceptual appropriateness of a given test. For example, does a mirror test for self-recognition tap the most appropriate sensory system to test a dolphin's self-concept? (For discussion, see Delfour's contribution.) And, to the extent that cognition is built on a species' perceptual and motor repertoire, how does that constrain the comparisons we can make across these very different taxa?

A second issue concerns the contrasting difficulties of working in a terrestrial vs an aquatic environment. For example, in the fully aquatic cetaceans, localizing which individual in a tightly clustered group is the one individual vocalizing may not be possible. How, then, do you look at vocal exchange between individuals with the same detailed level you might be able to look at with vocalizing chimpanzees? In addition, the range of specializations available to these animals also differs across such environments and may have impacted their adaptations—for example, the different physical placement of the eyes and the addition of “echolocation-attention” in cetaceans must alter how researchers approach the problem of social attention in these animals compared to primates.

Thirdly, interesting issues also arise in the sociology of comparative science. Primate researchers often appear unaware of, or unwilling to cite, the marine mammal literature on comparative cognition. In our discussion, Russon mentioned that this is sometimes because primate researchers face their own “battle lines,” such as those concerning the critical differences between humans and other primates, which leaves little time or space to devote to other taxa. Also, the primate cognition literature is vast, especially compared to that on marine mammals, and some researchers may feel it is a sufficient

field of reference for this area of inquiry. Furthermore, as Schusterman pointed out, much of the work on marine mammal cognition has been based on research that was pioneered with primates. Another issue that arises here may be our own species bias—our familiarity with primate behavioral signals and our ability to both expect and recognize such signals—which makes it much harder for us to interpret and incorporate information on the more alien marine mammals. Such issues can even affect funding agencies, whose research priorities understandably focus on humans, but who often underestimate the value of a broader base of comparison. As Herman pointed out in our discussions, crossing such taxa boundaries allows us to address intriguing convergence issues, such as why we do find such striking similarities in communication, intelligence, social structure, etc., across these divergent taxa. Developing, and accepting, species-appropriate tests that nonetheless enable us to make cogent, informative comparisons is certainly one of the greatest challenges facing researchers interested in studying marine mammal cognition.

8. *Expanding Beyond Cetaceans*—Although our workshop was designed to focus on

cetaceans and primates, Schusterman noted that cognitive research on pinnipeds also exists and by rights should be included in any discussion of marine mammal cognition (see Lindemann, Reichmuth-Kastak, & Schusterman, and also Deecke, this volume). Pinnipeds, sea otters, polar bears, and manatees all display behavior with interesting cognitive implications, and we would strongly encourage their further study. In fact, because some noncetaceans are semiterrestrial and are thus more accessible to research, we may well be able to answer some questions about them that will always remain a mystery in cetaceans.

9. *Archiving and Accessing Databases*—Because of both the great possibilities and great challenges of studying marine mammal cognition, we thought it prudent to suggest that researchers think about archiving their databases, especially video data sets, to maximize our abilities as a community to study the many details of complex behavior and cognition.

Finally, as guest editors, we also wanted to point out, as attested by the large and enthusiastic attendance at this workshop, that there is a tremendous interest in cognition and behavior in the marine



Workshop organizers and participants at the Marine Mammal Society Conference in San Diego, December 2007—Back Row (l to r): Adam Pack, Denise Herzing, Anne Russon, Rosi Karin-D'Arcy, Stan Kuczaj, and Volker Deecke; Front Row (l to r): Christine Johnson, Deborah Forster, and Lori Marino

mammal field. In recent years, however, this field has had little representation at conferences, workshops, and even in marine mammal journals. We encourage more submissions to each of these venues in hopes that the minds and behavior of these complex animals are incorporated into ecological, physiological, and life history projects on them.

As an attempt to continue productive dialog and move the field forward, we are establishing our conference website (<http://home.earthlink.net/~wdpdenise/>) for posting new tools, pertinent comments, and constructive ideas on these issues. Please e-mail Denise L. Herzing, wdpdenise@earthlink.net, or Christine M. Johnson, johnson@cogsci.ucsd.edu, to contribute ideas, experiences, and recommended software tools, etc. We will try to extract the most meaningful contributions and post them over time.

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