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Marine Mammals Enact Individual Worlds

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Scientific literature describes the various ways that we perceive animals and their contribution to our humanization. Our understanding of "animality" is changing, corresponding to an ever-increasing general knowledge of animals. Scientific studies provide objective descriptions of the complexity of animal worlds. The present article discusses recent findings on socio-spatiality, social cognition, and self-recognition in various marine mammal species, as well as the relevance and coherence of theories used to explain them. In a constructivist ethological approach, animals are not considered to be mere living organisms or objects, but rather, subjects. All animals use their senses to create relationships with their physical and social environments. Through their perceptions and actions, they give meaning to their surroundings; they enact individual and specific worlds, known as *umwelts*. The human-animal relationship is an intersubjectivity. Examples from studies of bottlenose dolphins (*Tursiops truncatus*) and killer whales (*Orcinus orca*) can be used to hypothesize the existence of a context-dependent situated self. Finally, animal welfare/well-being and the effectiveness of environmental enrichment programs can be re-evaluated in the context of this theoretical framework. In sum, no objective world exists; rather, we propose the existence of multiple context-dependent cognitive and subjective *umwelts*. The present article is the first to consider marine mammals with this perspective.

The relationships between humans and animals have always been paradoxical; for example, some humans cherish dogs as pets, whereas others may order dog meat from an exotic menu. In zoos, it is well known to employees that some species engender interest and compassion from visitors, while others seem invisible. Anthropologists, sociologists, and philosophers have clearly demonstrated that animals contribute to our humanization (Burgat, 1997; Fougea, Cyrulnik, & Matignon, 2001; Despret & Porcher, 2007; Fontenay, 1998). Application of the scientific method can help reveal the complexity of animal worlds objectively. For example, cognitive ethology, animal psychology, and philosophy can increase our knowledge of animals and our understanding of animality (i.e., the characteristics or nature of an animal) (Burgat, 1997; Fontenay, 1998). From a constructivist ethological perspective, the animal is a subject and the human-animal relationship is an intersubjectivity. The richness of this approach will be described and illustrated with examples from cetaceans' *umwelts*. This scientific perspective will be applied to a discussion of animal welfare and well-being.

Relevance and Coherence of Theories used to Study Marine Mammals

Reliable scientific questioning depends on a carefully chosen framework and on the relevance and coherence of the selected theories. Leaving the naturalistic or behavioral ecological approach behind, the combination of a constructivist ethological perspective and phenomenological questioning can be used to explore animals. In Greek, "phenomena" means "what appears" or "what is

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apparent," and "-logy" means "knowledge" or "science." Phenomenology is the study of the appearance and meaning of things, things as they appear in our experience, or the way that we experience things. This discipline explores conscious experience from the subjective or first-person perspective. Naturalistic approaches fail to consider artificial selection influences and do not take subjects and their subjectivity into account. Although behavioral ecological approaches offer advantages in the study of wild populations, they have serious limitations in research with captive animals. Limitations include the restricted number of animals that can be studied and the paucity of relevant behavioral ecological questions that can be addressed. In contrast, constructivist ethology considers the subjectivity of each individual's perspective.

This approach proposes that, through actions and senses, each animal ascribes meaning to its environment. Animals are not considered to be objects or organisms; rather, they are considered to be subjects who create what von Uexküll (1956) called an *umwelt* (the German word means "environment" or "surrounding world" but the term is usually translated as "subjective universe"). von Uexküll emphasized the role of the interactive relationship between a subject and its subjective world: the subject perceives the world ("merkwelt") through the sensory organs and sensory receptors, and acts on the world through its impulses and reactions ("wirkwelt"). Together, *merkwelt* and *wirkwelt* form the *umwelt*. von Uexküll theorized that two organisms in the same environment can have different respective *umwelts*. Body experiences determine the way that individuals construct the world and determine the development of individual perspectives on the world. The sensorimotor actions of a hummingbird, a polar bear, and a jellyfish are naturally different and result in the emergence of varied species-specific and individual *umwelts*. Although this theory is not recent, it remains relevant; above all, it is respectful of animals, their animality, and their subjectivity. Straus (1933), von Uexküll (1956), and Buytendijk (1958) developed a phenomenological psychology approach by applying psychological concepts to animals. These authors rejected experimental situations and mechanistic models, and chose instead to use a phenomenological approach to study animals' respective perspectives on their environments.

In recent articles, I discussed the limitations of Cartesian dualism and the benefits of the concept of "embodied/incarnated subjectivity" (Delfour, 2006a; Delfour & Carlier, 2004). Descartes' dualist conceptualization separated the thinking mechanism from its somatic origin and prevented scientists from considering animals as real subjects. "Embodied experiences" refers to the ways that a subject perceives or becomes conscious of its body, and to the ways that the body experiences the world (Gallagher, 2000). Merleau-Ponty's (1945, 1994) concept of the "body-subject" (an alternative to the Cartesian "cogito") is at the origin of the notion of "embodied cognition." In "Phenomenology of Perception," Merleau-Ponty developed the body-subject concept and emphasized that consciousness, the world, and the (human) body are mutually "embedded." From a phenomenological perspective, "incarnated/embodied" refers to cognitions based on the corporeal experience (via the sensorimotor interface) and individual

variability (biological, psychological, and cultural) (see Varela, Thompson, & Rosch, 1993). Ethology (the study and analysis of behavior in the context of specific stimuli), takes an external perspective on the subject. Action and perception are fundamentally inseparable, cognition depends on experience; and experience stems from the possession of a body with unique sensorimotor abilities. Knowledge is based on the world as we experience it. That is, knowledge is acquired through experience. The body is the subject's point of view on the world (Merleau-Ponty, 1945; Varela et al., 1993). Phenomenology allows a dual opening of subjectivity to the world and to others with an embodied temporal and imaginative consciousness (Merleau-Ponty, 1945). Experience of the world varies greatly and is dependent on the body. Several examples will illustrate this point. The first example is drawn from the human world and involves the experience of visiting the Eiffel Tower. If you have been to the top of the tower, you can describe the feelings that you experienced, whether you took the stairs or the elevator, and what you saw. If you have never been to the top of the Eiffel Tower, the experience can be described to you using technical information (e.g., height, weight, materials) and other people's personal perceptions, but you will never know exactly what it is like. If you visited the tower with another person or other people (e.g., a lover, your children), everyone had a different experience and each person constructed his or her own vision/representation of the Eiffel Tower. For example, your lover proposed at the top of the Eiffel Tower and your son vomited the hot chocolate and waffle with whipped cream that he had eaten just before climbing the tower. The Eiffel Tower is experienced subjectively; it has no objective existence. Actions, perceptions, and emotions color our world. Next, imagine going up the Eiffel Tower with your dog. Do you think that your dog knows that it is visiting a French monument built in 1889 and visited by over 200 million people since its inauguration? The dog's perception of the Eiffel Tower will be a mixture of various odours, such as a tasty 5-day old sandwich full of smelly cheese (do not forget, this is France) and the possibility of frequently marking its territory, etc. Parisian pigeons, mice, and cockroaches have different perceptions and representations of the Eiffel Tower. The Eiffel Tower is all of these perceptions and representations and much more! It embodies all of the possible actions, perceptions, and cognitions that contribute to the construction of an *umwelt* and allow us to ascribe meaning to our surroundings.

Another example comes from the prey-predator relationship. This relationship is not as predetermined as one might think. The protagonists construct the relationship and may construct it in a manner that ensures their survival. You may have heard stories about a dog adopting a cat, a lioness taking care of an antelope in Kenya (BBC News, 2002), or a tigress baby-sitting a half-dozen piglets in a Thai zoo (Thaizer, 2009).

Depending on several factors (context, reproductive status, physiological and ethological needs, etc.), animals create different relationships with their environments and ascribe different meanings to their surroundings. No objective world exists: rather, multiple context-dependent cognitive and subjective worlds/*umwelts* emerge. In the present article, I propose that this concept is equally

applicable to dolphins. Dolphins make sense of their surroundings through their actions, cognitive abilities, and sensory modalities. All dolphins enact individual worlds.

Animal welfare and well-being

A further advantage to adopting an ethological methodology is that it considers animal welfare and well-being, and creates several indices with which to measure these variables. Welfare and well-being are clearly defined in the literature in this area (Broom, 1991; Dawkins, 1990; Delfour & Lassalle, 1996; Fraser, 2009). Well-being is related to mental state and to subjective experiences (Dawkins, 1990; Wemelsfelder, 2005) such as boredom, mental suffering, anxiety, and frustration, among others. Five criteria have been established to measure welfare and well-being in animals. They are referred to as the five freedoms (Brambell, 1965; O.I.E., 2002):

F1: Freedom from hunger, thirst, and malnutrition
F2: Freedom from physical discomfort
F3: Freedom from pain, wounds, and sickness
F4: Freedom from fear, stress, and distress
F5: Freedom to display the species' behavioral repertoire

Determination of the last criterion is difficult because we do not know the complete dolphin ethogram. Moreover, being chased by a predator, killed by a shark, or suffocating in driftnets are all part of the species' repertoire, but we do not necessarily want captive dolphins to experience these situations or display these behaviors. There are obvious limitations to the last criterion.

There are several traditional ways to evaluate welfare and well-being in animals. The first involves analyzing the richness of the animal's behavioral repertoire, testing the animal's preferences, establishing the presence or absence of stereotypy, and measuring hormone secretions in the pituitary and adrenal glands. The first three variables are easily accessible via observation and indices of behavioral parameters. Ethology allows researchers to indirectly or directly question animals (e.g., tests of preferences) and to measure their welfare and well-being. Cognition offers the opportunity to study the ways that animals process information. Finally, phenomenology can be used to investigate the experienced world of animals. Embodied cognition involves the identification of a strong relationship between body and mental states. This framework emphasizes the important role of emotions in cognitive processes, and reconsiders unconscious thought mechanisms. Embodied cognition acknowledges the evolution of data in different animal species' brains and the ways that animal societies are built and evolve.

The use of this combined approach (ethology and psychological phenomenology) avoids drawing public attention to charismatic species and/or species that tend to elicit emotions in humans, such as dolphins. Sea lions are one example of a species that is too often under-considered or overlooked altogether. The approach presented here uses tools that can be equally applied to investigate

the enacted worlds of dolphins, sea lions, walruses, and polar bears, among others. The combined approach considers each animal to be a worthy subjective being whose behavior cannot be qualified as aberrant. The use of this approach also prevents speciesism or questionable ethical positions, such as "It is unethical to keep dolphins in captivity because they are intelligent animals." According to this position, only animals with large brains deserve rights and consideration! Is cognitive capacity a legitimate variable with which to justify a position about animal rights? Is this hierarchy ethical? This issue begs many questions that would benefit from discussion in multidisciplinary committees. The study of ethics, the philosophical study of moral values and rules, is complex. In Greek, *êthos* means moral disposition and the privilege of theoretical thought; among other issues, ethics involves questions about freedom, dignity, and relationships to others. It is impossible to be strictly and entirely ethical; as humans, we are only capable of relative morality, which dictates that we avoid inflicting unnecessary suffering. Ethics cannot be limited to the dimension of moral experience, but comprises other modalities as well (Levinas, 1988), depending on theoretical background. For instance, some elements of the utilitarian approach developed by Bentham (1748-1832) and Mills (1806-1873) merit reexamination (Mulgan, 2007). According to these authors, living beings that suffer or experience pleasure have interests; morality therefore consists of defending these interests and ensuring that pleasure will be increased and suffering diminished for all beings susceptible to pleasure and suffering. Varela's discussion of cognition and the enactive approach provides valuable insight. According to this author, abstraction is too strongly developed and results in the establishment of a critical morale, detached from practical perspectives (Varela, 1996). Future research into these perspectives is very important and will clarify the issues presented here.

Insights into the Perceptual and Cognitive Worlds of Marine Mammals

The scientific paradigms presented below focus primarily on (social) cognition, self-recognition, neuro-ethological issues, and animal welfare, using the animals' subjective perspectives. The experiments presented here were conducted with the spontaneous participation of the animals, without food reinforcement (Delfour, 1997, 2005, 2006b, 2007; Delfour & Carlier, 2004; Delfour & Marten, 2001, 2005, 2006).

Marine mammal socio-spatiality

The combination of social organization and spatial distribution of behaviors in captive species arouses interest in animal behavior scientists (Bettinger, Wallis, & Carter, 2005; Leighty, Soltis, & Savage, 2009; Mechkour, Maublanc, Bideau, Gérard, & Pépin, 2007; Ogden, Lindberg, & Maple, 1993; Roberts & Khon, 1993; Robitaille & Prescott, 1993). Studies conducted on groups of beluga whales (*Delphinaterus leucas*) at the Vancouver Public Aquarium (three females: 22, 10 and 5 years old, and 2 males: 10 and 5 years old) and at SeaWorld

Florida (three females: 19, 12 and 10 years old, and one male: 12 years old) demonstrated that white whales use socio-spatiality to structure their 3D environments (Delfour, 1997; Delfour & Aulagnier, 1995). A focal-animal sampling method (Altmann, 1974) was used to study the interactions between the subject and its habitat in beluga whales. According to age, sex, reproductive status, and behavior, the animals interacted with their environment in different ways. Young belugas and female belugas swam in central areas of their pools, whereas males tended to investigate the periphery. Agonistic and aggressive behaviors were preferentially displayed close to the surface of the water, and submissive animals sought shelter in shallow areas following negative encounters (e.g., aggression). In one group of belugas, the whales seemed to have divided their habitat into several different social areas. The different environment in each dolphinarium permitted the analysis of vertical and horizontal organization of space. Among other things, the results presented here could be used to improve the architectural design of the habitats of cetaceans (e.g., creation of shallow areas where submissive animals could hide, creation of areas hidden from the public, development of variations in water movement to make the environment more dynamic and more diverse, etc.). Previous ethological studies with other species have demonstrated that this type of study can yield valuable insights that can inform captive population management and habitat improvement (Forthman Quick, 2005; Hebert & Bard, 2000; Renner & Kelly, 2006; White, Houser, Fuller, Taylor, & Elliott, 2003; Zucker, Deitchman, & Watts, 2005).

Examples of marine mammal cognition studies

In the two beluga whale groups described above, the establishment of a cohesive group was based on and maintained by affiliative behaviors and by the hierarchical status of the oldest female (Delfour, 1997). An ethological study of a group of bottlenose dolphins (*Tursiops truncatus*) at Asterix Park in France demonstrated that dolphins displayed primarily affiliative behaviors; further, coefficients of associations between animals (via the Half Weight Index) revealed that associations between dolphins were not random. Common pairings included a mother-calf dyad, a dyad of two older males, and a dyad of two juvenile females (Estrade, Mercera, & Delfour, 2009). In another *Tursiops* group at Sea Life Park, Hawai'i, the dominant female dolphin displayed less neophobia (i.e., tendency to avoid or retreat from an unfamiliar animal, object, or situation) than did her two poolmates. Further, interindividual relationships played an important role in the process of learning a specific cognitive task (i.e., an intermodal associative task) (Delfour & Marten, 2006. In the Sea Life Park experiment, three female bottlenose dolphins were submitted to a two-choice, three-choice, or four-choice visual task, and a simultaneous auditory discrimination problem, without food reward. Since the dolphins were not isolated, we were able to examine the role of identified social constraints on the learning process. The dolphins allowed the dominant female priority access to the experimental apparatus; her conspecifics developed alternative problem-solving strategies. The study design allowed us to investigate

the influence of social facilitation, while inhibiting individual behavioral expression. The subjects seemed to experience the situation differently, depending on their social relationships: for example, one female adopted emulation learning to solve the proposed cognitive tasks. In short, dolphins used different strategies to solve each "problem" presented to them. In another experiment, dolphins (*T. truncatus*) demonstrated the ability to process intermodal information by using an underwater touch-screen to associate simple visual forms (2D and 3D geometrical figures), dolphin/human video sequences, and auditory information, without food reward (Delfour & Marten, 2005) (Fig. 1). The results (i.e., the influences of social organization and cognitive abilities) should be considered in planning future marine mammal enrichment programs.

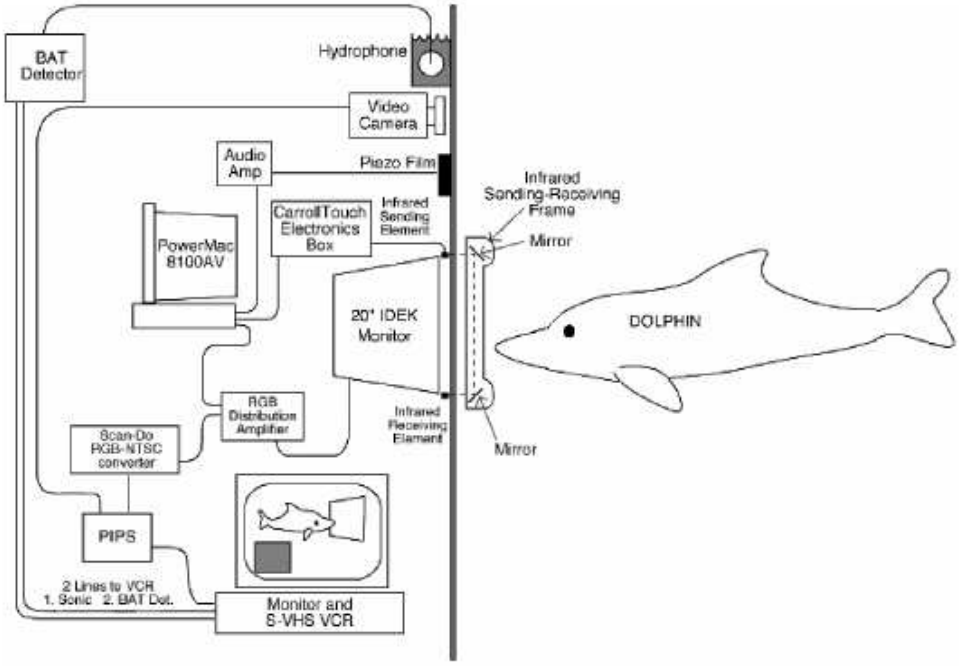


Figure 1. Dolphin operating an underwater touch-screen. Delfour, F., & Marten, K. (2006).. *Behavioral Processes*, *71*, 41-50.

Reevaluation of self-recognition and signature whistle theories

Researchers use several tools to investigate self-recognition in marine mammals, including the mirror test (subject is placed in front of a mirror and observed), the mark test (subject is marked when asleep and subsequently placed in front of a mirror), video sequences of a subject (real time versus playback videos) and finally, the use of signature whistles.

The mirror and mark tests in cetaceans and pinniped. Mirror and mark test experiments have been conducted with bottlenose dolphins (*Tursiops truncatus*) (Marino, Reiss, & Gallup, 1994; Marten & Psarakos, 1994; Reiss & Marino, 2001),

killer whales (*Orcinus orca*), false killer whales (*Pseudorca crassidens*) and sea lions (*Zalophus californianus*) (Delfour & Marten, 2001). The animals had access to a mirror or other reflective surface (e.g., reflective glass walls; Reiss & Marino, 2001) in their pool. Their behavior was videotaped and compared to their behavior in control situations, such as absence of a mirror (tested in all species), covered mirror, unmarked animal, behavior in the presence of an unfamiliar conspecific (tested in bottlenose dolphins), behavior through an underwater barred gate, and social interactions (tested in false killer whales, sea lions and killer whales). Bottlenose dolphins (Marino et al., 1994; Marten & Psarakos, 1994; Reiss & Marino, 2001) and killer whales (Delfour & Marten, 2001) showed evidence of self-directed and contingency checking behaviors in front of the mirror. False killer whales' behavior was more difficult to interpret: their actions were similar to social behaviors, with implemented long sequences of open-mouth behavior. Finally, sea lions did not display clear self-directed behaviors (Delfour & Marten, 2001).

The mirror mark test. Given the impossibility of anaesthetizing marine mammals, researchers generally sham-mark subjects with non-toxic markers (e.g., water-filled markers or Vaseline) or non-toxic real markers (e.g., zinc oxite, gentian violet, ichthammol) (Marten & Psarakos, 1994), temporary black ink Entré markers (Entré, Westborough, MA) (Reiss & Marino, 2001), or antiseptic ointments (e.g., Mitosyl and Dermobion) (Delfour & Marten, 2001). Sham-marking was used as a control condition. Bottlenose dolphins examined their bodies thoroughly, spending more time observing the marked part than other parts of the body (Marino et al., 1994; Marten & Psarakos, 1994; Reiss & Marino, 2001). Mixed results were observed in killer whales: one of the females rubbed her marked rostrum against the wall (Delfour & Marten, 2001).

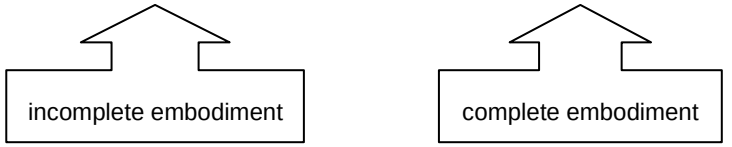
Video sequences. To distinguish self-examination from social behavior in the context of dolphin/mirror interaction, Marten and Psarakos (1995) conducted additional experiments using self-view television sequences in real time *versus* playback mode. When presented with real time videos of themselves, adult dolphins displayed self-directed behaviors. Three juvenile dolphins spent more time looking at their image in the real time situation than in the playback mode. Marten and Psarakos (1995) marked the animals (on their sides and mouths), primarily in real time situations, and observed that the dolphins positioned themselves preferentially so as to have visual access to the marked body parts in the mirror. Next, Marten and Psarakos (1995) alternated real time frontal self-view and side self-view on the television screen; they observed that the animals turned their bodies to facilitate self-examination. From the absence of social behaviors and the display of self-directed and contingency checking behavior, the researchers concluded that the dolphins viewed their television image as a representation of themselves, rather than as a conspecific.

Video sequences and signature whistles. Following the proposal of the "signature whistle" hypothesis [i.e., stereotypic individually distinct call used by the animal to label or name itself or another animal (Janik & Slater, 1998)], we studied dolphins' ability to associate a given dolphin's signature whistle with a visual representation of that dolphin. We designed an innovative experimental procedure:

three adult female dolphins were exposed to an underwater touch-screen. The signature whistle of the son of one of the three dolphins was emitted in the pool (Delfour, 2005 Delfour & Marten, 2005). A video of the son was simultaneously presented on the touch-screen. The production of the signature whistle solicited an intense reaction in his mother [i.e., prolonged time in front of the apparatus and frequent rubbing against the touch-screen (Delfour & Marten, 2005)]. From the perspective of embodied cognition, a subject's cognition relies on the body's sensory and motor experiences and the context. Revisiting the self-recognition paradigm with a combined phenomenological questioning and cognitive ethological approach, we suggested the presence of a context-dependent situated self (Delfour, 2006b; Delfour & Carlier, 2004). In some circumstances, self-recognition may be limited to the recognition of body movements or body parts; however, this procedural knowledge is not always sufficient or adequate. We used Rochat's (2003) and Gallagher's (2000) work to develop an analysis grid to describe the use of the specular image and the construction of body image in various animal species (Table 1). Delfour and Carlier (2004) suggested a process that gradually moves the animal from a state of fusion (body image is absent) toward a state of *distanciation* wherein the animal envisions itself in various ecological, individual, and social contexts. More recently, a similar analysis has been conducted with free-ranging Atlantic spotted dolphins (*Stenella frontalis*) in the Bahamas (Delfour & Herzing, 2009). From a hasty look at the preliminary results, we could conclude that spotted dolphins are not capable of self-recognition. However, caution should be used in making this interpretation. We question the appropriateness of the experimental setting and the relevance of the questioning in this particular context. In contrast to previous studies of captive bottlenose dolphins, the mirror did not draw very much interest from the wild spotted dolphins. These results corroborate our hypothesis of the existence of a "situated consciousness" that depends on the context and on the animal's degree of interest.

Table 1
The construction of the body image in the self-recognition process. Delfour, F. (2006). *Aquatic Mammals, 32,* 517-527.

Construction of the body image and emergence of self-consciousness						
Process/ environment	Fusion (base)	Differenciation	Decentration	Decentration/ recentration-comparison	Distanciation; situated self	Distanciation, stabilised self in social space and time
Mirror test	Nonpertinent	Failure	Failure	Failure	?	Success
Use of specular image	None	Reflection ≡ conspecific	Interest without specific reaction	Interaction with the reflection, intermodal link	Comparison of specular /body image	Comparison reflection/ corporal image: stable reactions



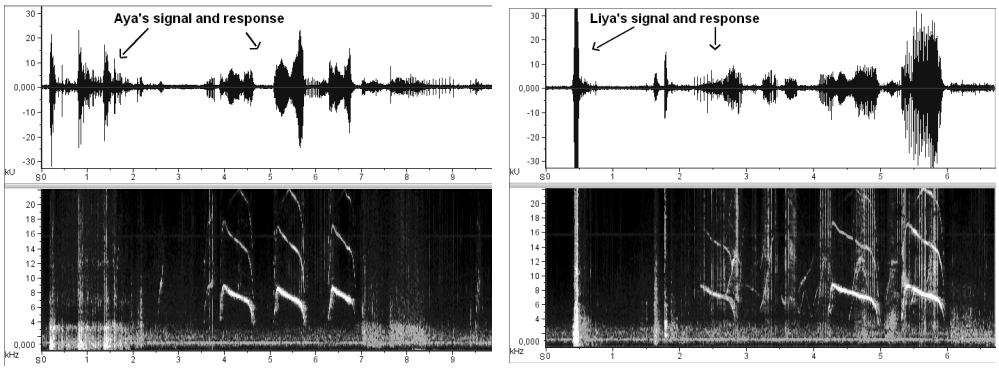


Figure 2. Waveforms and spectrograms of a young adult female dolphin (Aya) and her daughter (Liya) responding to their acoustic signals in an experiment at Asterix Park.

Some neuro-ethological particularities

In an intermodal cognitive task, dolphins were demonstrated to preferentially use monocular vision, but did not seem to prefer one eye over the other (Delfour & Marten, 2006). We taught three bottlenose dolphins an association between an underwater acoustic signal and a visual stimulus displayed on an underwater touch-screen. We presented the dolphins with animated 2D and 3D geometrical figures, as well as dolphin/human video sequences. For each trial, we used two, three, or four auditory stimuli chosen from four different pure tones, a known dolphin whistle, and one human word. The dolphins' individual scores (number of correct answers) were correlated with right eye vision (Table 2). That is, dolphins appeared to have a right visual field advantage in processing visual information, even when simultaneously processing acoustic information. This result provided further evidence for a left hemispheric dominance for visual information processing in this species (Kilian, von Fersen, & Güntürkün, 2005; von Fersen, Schall, & Güntürkün, 2000).

Table 2
Correlations between individual dolphins' number of correct and incorrect answers and chosen vision (binocular and monocular (left and right eye). Correlation matrix results (r computed for every pair of variables).

Vision mode	Correct answers			Incorrect answers		
	Dolphin 1	Dolphin 2	Dolphin 3	Dolphin 1	Dolphin 2	Dolphin 3
Binocular vision	0.223	-0.026	0.319	-0.125	-0.116	-0.038
Left eye vision	0.325	0.094	0.650	0.175	0.270	0.346
Right eye vision	-0.072	0.294	0.767	-0.037	0.089	0.284

A general understanding of the cognitive world of dolphins is necessary to understand their incarnated cognition and to improve their welfare and well-being. Information on dolphins' socio-spatiality revealed that dolphins ascribe different meanings to various areas of their habitat. Consequently, we can hypothesize that dolphins may feel more comfortable in some areas of their habitat than in others, and that their preferences could impact appetite/food intake, neophobia, learning abilities, and performance in training exercises, among other variables. It has been demonstrated in a group of captive dolphins that social facilitation (e.g., emulation learning) and inhibition influence the expression of an acquired behavior. The practical applications of this finding are numerous; some dolphins may learn preferentially in pairs, whereas others would benefit from being separated from others (e.g., to improve learning, motivation, etc.). Moreover, unstable dominance hierarchies, changes in group dynamics, and competition over resources are considered to be potential stressors for bottlenose dolphins (Waples & Gales, 2002). The finding that bottlenose dolphins can easily handle intermodal information supports the idea of enriching dolphins' environments by combining visual, auditory, and tactile stimuli (e.g., underwater touch-screen displaying sounds and visual stimuli) (Hoy, Murray, & Tribe, 2009). Findings from self-recognition studies provide further interesting perspectives on animal welfare/well-being. It has been demonstrated that mirrors temporarily enrich the environment of some animals in partial isolation. For example, mirrors have been demonstrated to reduce stereotypic behavior in horses (McAfee, Mills, & Cooper, 2002) and decrease stress responses in sheep (Parrott, Houpt, & Misson, 1988). Extrapolating from these findings, we can imagine that, in particular and precisely controlled situations (e.g., temporary isolation), we could improve the well-being of marine mammals that didn't pass the mirror test by giving them the opportunity to extend their visual field or to interact with a "new companion" (i.e., their specular image). Finally, information on neuro-ethology is valuable for animal welfare. The inclusion of simple behavioral tests (e.g. monocular/binocular vision, eye preference, motor laterality, etc.) in veterinary examinations could provide information about general health status and (in some cases) brain lateralization in animals, and facilitate early detection of serious medical problems.

Future avenues for scientific research

Some of the studies described here will be replicated and will test hypotheses about a variety of topics (e.g., signature whistles and social cognition; enrichment programs). From my perspective and my experience in the field (documented in several published scientific papers), experimental research (i.e., research using underwater touch-screens, learning tasks, etc.) appears to fulfill animals' cognitive needs. We believe that marine mammals have great abilities and a large capacity for learning; however, some humans may deprive these animals of this opportunity. Even without food reinforcement, marine mammals are willing to participate and often appear eager to be the first to engage in an experiment or to

access an experimental apparatus. The development of non-intrusive experiments that are interesting for animals will permit us to increase our knowledge about their biology, psychology, cognition, etc.

Recently, Asterix Park in France launched a European-wide (and, hopefully, soon-to-be international) study designed to increase understanding of individual dolphins. Using standard ethological methods (Altmann, 1974), a behavioral profile for each dolphin will be established. The objective is to improve the management of social groups, animal welfare/well-being, and husbandry sessions (i.e., training sessions, transportation, etc). Moreover, an innovative set of studies has been initiated to investigate what constitutes enrichment for dolphins. Is it enough to put a ball in the pool and reinforce dolphins when they touch it? Does this type of activity improve animals' welfare and well-being? At Asterix Park, dolphins freely interact with objects placed in their pools, with no human reinforcement (i.e., no whistles, food, or vocal encouragement). Our preliminary results demonstrated that different animals interacted with the objects in different ways (interest versus manipulation) and that the oldest female interacted with the objects more than did her younger conspecifics (Beyer, Mercera, & Delfour, 2010). Future investigations will be conducted to clarify the roles of enrichment programs on animal welfare and well-being. By studying dolphins' behavior with objects, we will improve our understanding of the meanings that they give to the objects (e.g., something to chew on, something to push, something to throw in the air, etc.). The animals' actions will reveal the meaning that they ascribe to their surroundings. Significant efforts will be made to disseminate the scientific results of these projects to the general public. We are determined to make our findings accessible in the future to individuals with an interest in animal science.

In sum, a clearer understanding of the ways that dolphins construct their perceptual worlds is gradually emerging. Dolphins use their senses and their actions to create relationships with their physical and social environments. They give meaning to their surroundings; that is, they enact an individual and specific world, an *umwelt* [a "subjective universe" that represents the "biological foundations that lie at the very epicentre of the study of both communication and signification in the human and non-human animal" (von Uexküll, 1956)]. Animal activity is closely related to the external world; animals' expressive movements reflect attitude and precede action designed to achieve a meaning or a goal (Buytendijk, 1952). Animals are not only living organisms, they are subjects.

Experiencing the World from a Unique Perspective

The combined approach (ethological and psychological phenomenology) promotes a reevaluation of animal welfare and well-being. For example, this approach questions the search for realism that many animal facilities undertake. A facility that fulfills human aesthetic standards does not guarantee that animals will act, perceive, or enact a world similar to the world that they would experience in the wild. Rather than attempting to recreate the wild, we may wish to observe how

animals enact their world in a particular situation (i.e., in captivity). An imitation of the natural habitat could limit captive animals for a number of reasons; we will never succeed in gathering and properly combining all of the factors of the wild environment, and the artificial habitat will always be a pale imitation. An assumption or belief common among visitors to animal facilities is that animals possess archaic knowledge of their species' history. That is, that even animals born in captivity have an intrinsic knowledge of the experience of living in the wild. The animals are believed to have expectations and, if their keepers do not fulfil them, the animals' welfare suffers as a consequence. Moreover, many people believe that an objective world with the same fixed (determined) characteristics exists for everyone (perceptually, cognitively, etc.). If you have ever seen dolphins playing with a mop, you may understand. The probability of a mop entering a wild bottlenose dolphin's world is highly unlikely. However, if the presence of a mop as an object to drag, bite, or rub against enhances social activity and reduces stress level, it could be worth proposing to captive animals. I am not sure whether or not a very realistic artificial (concrete) reef would elicit the same interest; dolphins would probably direct different actions toward a concrete reef. Belugas provide an interesting example: I witnessed caregivers putting live fish into a pool of beluga whales (personal observations, 1998). The whales did not eat the fish; instead, they used the fish as live bullets. One beluga carried a fish in its mouth and spit it out in front of the public, eliciting screams, laughter, and applause. This excitement probably constituted some form of reinforcement for the animal. Moreover, as previously described, a single object (e.g., a mirror) has different meanings and elicits a variety of behaviors (e.g., exploration of the surroundings, affiliative or aggressive behavior, self-examination, no reaction) in marine mammals. According to the *umwelt* perspective, the subject ascribes meaning to its environment through its actions. We can assume that an enrichment program would be effective if an animal succeeded in ascribing meaning to change (e.g., dietary, social, psychological, cognitive) in its environment and finding a benefit to the change (Delfour, 2010). Moreover, two studies conducted at Asterix Park in France demonstrated interspecific stimulus enhancement in sea lions and bottlenose dolphins; a decrease in neophobia and an increase in individual interest in the surroundings were observed (Lamoise, 2006a, b). The animals included trainers in their enacted worlds. Various studies have demonstrated that joint attention between dolphins and humans is possible [i.e., gazing and pointing gestures (Pack & Herman, 2006, 2007)]. There are many remaining avenues for research in human/marine mammal relationships (e.g., interspecies communication).

I conduct research on both captive and wild marine mammals. Links between the two populations can be demonstrated; some research findings from studies of captive animals are applicable to their wild counterparts and others are not. This is not a reasonable rationale for keeping or not keeping dolphins in captivity. An intolerant approach to the question of captive animals is reductionist; it limits the research that can be conducted and the subsequent benefits to the animals. It is not reasonable to consider captive dolphins to be guinea pigs for

studies about their wild counterparts; captive dolphins are much more than that, as discussed above. Studies of animals in captivity permit access to individual animals. Such studies allow us to closely control and measure certain variables and permit us to conduct long-term studies. Much remains to be learned from captive animals (e.g., cognitive and acoustic abilities). Facilities that house captive animals offer a truly unique opportunity to study the ontogenesis of various processes (e.g., psychological, ethological, cognitive) and to test new techniques and equipment in captivity before using them in the wild. However, we must ensure that we do not minimize the direct benefits for captive animals; they should be first to benefit from scientific research findings. The physiology and behavior of captive dolphins is often distinct from that of wild dolphins; captive dolphins provide a great opportunity to observe how animals adjust to captivity. As discussed above, we can learn from captive dolphins (e.g., behavior, cognition, acoustics) and apply the findings to wild populations. Captive marine mammal facilities could be a great place to educate the public about marine animals and their needs, and could motivate more people to become involved in conservation efforts. However, misperceptions about studies of captive marine mammals create idealization, or, at minimum, a hierarchy of research conducted on animals in the wild *versus* research conducted on animals in captivity. Yet, the same scientific standards and ethical issues apply for both settings. Both types of research are subject to evaluation of the relevance of the projects, their procedures, their conformity with ethical standards, and their impact on the animals. Who would benefit from a potential schism between researchers conducting studies with captive animals and those conducting studies with wild animals? Some research questions are best answered with one or the other population. Challenges will arise for both types of study and our focus ought to be on overcoming the challenges and moving forward. For example, future research may wish to focus on aging in the captive population, the general lack of information about geriatric animals, or the rich and complex interspecific communication that develops between dolphins and their trainers (e.g., joint attention, pointing), among other points of interest. Finally, greater efforts should be put into animal rehabilitation projects.

In our occidental culture, romantic or mystical beliefs designate dolphins as messengers. Dolphins are imbued with positive human qualities, and often elevated to the divine (Delfour, 2007). Some believe that dolphins can act as co-therapists. Unfortunately, dolphins' curative powers are not easily incorporated into the rationality and objectivity of the scientific approach. Interestingly, captive and wild dolphins engender different beliefs and representations, fed and maintained by secular myths and legends of wilderness beauty. These various occidental beliefs, based on a mix of scientific misconceptions, anthropomorphic interpretations, and fantastical psychic construction, lead to unfortunate misunderstandings and deconstruction of dolphin animality and subjectivity (Delfour, 2007). The creation of falsely homogenous groups ("captive dolphins" versus "wild dolphins") ignores the diversity present in these artificial categories.

The approach presented here has major epistemological limitations (e.g., using *sensus stricto* in animal terms, based in the human linguistic and symbolic

system of reference) and methodological limitations (e.g., aquatic vs. non-aquatic mammals). However, advantages of the combined approach include progress toward greater knowledge and the development of new questions, such as the following: “How do animals perceive problems? Do scientists and dolphins experience a cognitive task conceived and designed by humans similarly? What constitutes enrichment for a walrus? How does it compare to enrichment for a harbour porpoise?” The combined approach allows consideration of the permeability between the human *umwelt* and the animal *umwelt*.

Although we will never know what it is like to be a sea lion, dolphin, sea otter, or polar bear, by increasing our knowledge about these animals, we will gain a better understanding of their worlds and consequently, be able to treat them with the respect that they deserve.

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