Aquatic Mammals 2022, *48*(6), 720-723, DOI 10.1578/AM.48.6.2022.720

Social Transmission of Innovative Sound Production in Walruses (*Odobenus rosmarus*)

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Within a zoological setting, a male Pacific walrus (*Odobenus rosmarus divergens*) spontaneously used a toy as an instrument to produce an underwater sound in a specific manner and location. This peculiar behavior persisted over several years and was eventually acquired by two of three same-aged conspecific females. We believe this opportunistic finding demonstrates tool-based innovation in sound production and establishes the potential for social transfer of complex behaviors in this species. Given limited available documentation of similar occurrences in other mammals, these observations of walruses are described within the context of social learning and species-typical behavior.

Examples of acoustic plasticity, tool use, and social transmission of arbitrary behaviors remain rare for non-human mammals (see Heyes & Galef, 1996; Janik & Slater, 2000; Byrne, 2002) and especially for carnivores (see Box & Gibson, 1999). Anecdotal descriptions can help determine the possible relevance of these topics to different animal groups. Pinnipeds are amphibious carnivores with notable cognitive skills (Schusterman & Kastak, 2002; Cook et al., 2021; Hanke & Reichmuth, 2022) and demonstrated flexibility in sound production (see Reichmuth & Casey, 2014). However, there is no substantive evidence that pinnipeds use tools (Mann & Patterson, 2013) or learn through observation of actions performed by others.

Walruses are among the most vocal marine mammals and the most social pinnipeds. They live more than 30 y and have an extended period of maternal dependency, with calves gradually weaned by 3 y of age. Little is known about their fine-scale social structure, but accumulating evidence suggests the potential for long-term bonds (see Miller & Kochnev, 2021) that could provide opportunities for learning from familiar individuals.

Males and females produce social sounds in air and water that vary in amplitude, duration, pitch, bandwidth, frequency modulation, and other characteristics (see Charrier, 2021). Not all sounds have laryngeal origins or involve the expulsion of air through the nostrils or mouth (Schusterman, 2008). Features of the mouth, lips, tongue, and muzzle related to suction feeding and specializations of the respiratory tract related to buoyancy and breath control support the production of unusual and graded sounds (Tyack & Miller, 2002), including buzzes, clicks, rasps, whistles, barks, growls, and moans (see Fay, 1960; Schevill et al., 1966; Schusterman & Reichmuth, 2008). Additionally, mature males emit complex underwater "songs" during the breeding season. These non-vocal acoustic displays comprise predictable sequences of intense knocks, taps, clanging gong-like sounds, and harsh whistles that are relevant to male competition and possibly female choice within a polygynous breeding system (Sjare et al., 2003).

Herein, we describe the invention and social transfer of an unusual sound-producing behavior within a group of four adolescent Pacific walruses, a male and three females, that were reared in human care at Six Flags Marine World in Vallejo, California. These individuals were highly interactive with one another and with their environment. It is well known that captive walruses orally explore and often damage structural features in their living spaces, presumably as a byproduct of natural suction feeding behavior (Fay, 1982). In this situation, a bolt associated with a window frame was removed by one or more of the walruses, leaving a space in the wall behind the frame where the bolt had been. This surface defect remained accessible to the walruses for several years until the pool was repaired.

During the time this feature was present, the walruses had occasional access to a rubber "tug" toy as part of routine behavioral enrichment (Figure 1). While all four walruses carried and manipulated this toy, the male spontaneously began to use it in a purposeful way in 1999 when he was 5 y old. He would carry the toy in

Figure 1. The male walrus (*Odobenus rosmarus*), "Sivuqaq," photographed through the window with the instrument he used for sound production. See Supplementary Video 1 for examples of his sound-producing behavior. (*Photo credit:* C. Reichmuth, 10 January 2006)

his mouth to the window, carefully position it at the position of the bolt hole, and "buzz" the toy in such a way that a sharp trumpeting sound was produced. This sound was continuous (> 1 s duration) or patterned in discrete pulses (see Supplementary Video 1; this video is available in the "Supplemental Material" section of the *Aquatic Mammals* website: https://www.aquaticmammalsjournal.org/index.php?option=com_content&view=article&id=10&Itemid=147). The sound amplitude was greater than the common moan vocalizations produced by this individual (> 166 dB re 1 µPa; Reichmuth et al., 2009). The behavior always occurred in the same location. It persisted intermittently for more than 3 y during periods when the toy was available in the enclosure until the window frame was repaired.

The male's unusual sound production elicited strong and immediate responses from the conspecific females, who oriented to the male and crowded tightly around him as he performed the behavior (Supplementary Video 1). All three females were observed to produce components of the male's actions (Supplementary Video 1). Eventually, two females performed the complete behavioral sequence demonstrated by the male—carrying the toy to the appropriate location at the window frame, placing the rubber toy carefully at the position marked by the bolt hole, and emitting similar trumpeting sounds. The females' acquisition of the trumpeting behavior occurred within a year of our initial observations. While not captured to video, the females' responses were documented in behavioral records and verified by at least two observers on the animal care staff (one of the authors, DQ, and T. Rael, pers. comm., 16 May 2022).

The mechanism of sound production in these instances was unclear. No air bubbles were visibly released during the behavior, suggesting the vibration of the toy was not a consequence of air exhalation through pursed lips. Rather, the walruses may have produced the sound by sucking water over the rubber toy into the mouth or by jetting water out of the mouth over the toy. The role of the anomalous surface feature in the pool where the behavior occurred is also ambiguous from our observations and limited recordings. What is apparent is the consistent use of the toy as an instrument or tool to create a novel, attention-getting sound in a predictable and directed manner.

This odd form of sound production has several aspects that are relevant to social transmission of complex behavior. First, the behavior is both arbitrary and complex (multi-stage) and does not occur as an innate or species-typical behavior. Therefore, we can be relatively certain that expression by observers would not occur by chance. The behavior was expressed exclusively in a particular location, suggesting that local enhancement (facilitation of learning that results from drawing attention to a place) might play a role in behavioral transfer. Similarly, as the behavior occurred only with a particular toy, it is possible that stimulus enhancement (facilitation of learning that results from drawing attention to an object) could play a further role (see Zentall, 2006). However, given the specificity and arbitrary nature of this goal-directed behavior, the most likely explanation for behavioral transfer may be true imitation. Social transmission of behavior through imitation is difficult to demonstrate in animals. It occurs when an individual copies the form of an observed behavior, particularly an otherwise improbable action or utterance for which there is no instinctive tendency (Zentall, 1996).

In this case, we note the absence of food reinforcement and the apparent significance of social cues (attention, vocalizations, tactile stimulation) provided by the observing or "listening" individuals. The male's sound-producing behavior captured our own attention immediately as we observed him through the window. It seems likely that the male's innovative behavior created a very salient signal that provided the opportunity for the female walruses to closely attend to his actions, the object, and the specific location.

Interpreting these observations in relation to the typical behavior of walruses is difficult. There are few descriptions of behavioral development in walruses, including responses associated with feeding, communication, and social interactions. The suction and hydraulic jetting used during underwater feeding on bivalves (Levermann et al., 2003) certainly seems related to the expression of this acoustic behavior. Novelty in sound production may have additional relevance to walruses as they are known to exhibit acoustic plasticity (Schusterman & Reichmuth, 2008). Further, the patterned songs of wild males are known to vary contextually and over successive seasons (Sjare et al., 2003). It is possible that social learning of complex behavior occurs among walruses in natural situations but has not yet been documented in the field. By sharing this anecdote from our time spent with walruses in a zoological setting, we highlight the unique nature of these marine mammals and add to early descriptive reports of their unusual behavior and sociality (see Fay, 1982).

Acknowledgments

Dr. Ronald Schusterman was with us for initial observations, and we share this account in memory of his contagious enthusiasm. We thank Six Flags Marine World (now Six Flags Discovery Kingdom) for providing access to animals, animal care staff, and husbandry records. We thank Shannon Spillman, Jon Brininger, Brian Lynn, Jessie Cramer, and Billy Hughes for assistance with documentation and Caroline Casey, Jillian Sills, and Kathleen Dudzinski for manuscript review. The observations reported here were obtained without harm to animals in compliance with the laws of the United States and with approval from the Animal Welfare Committee at the marine park and the Institutional Animal Care and Use Committee at the University of California Santa Cruz.

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