Psychophysiological Mechanism of Therapeutic Dolphin - Human Interactions

by

Ilanit Tof

Email: ilanit@littletree.aust.com

Contents

Abstract

The emerging field of dolphin assisted therapy is reviewed. The paradigm is traced from its roots in cognitive behavioural techniques, in which it enjoys success with developmentally and cognitively challenged children. Parallels with other animal assisted therapy are considered. The recent foray into neurophysiological evaluation, with electrochemical implications, is discussed. Interdisciplinary knowledge is synthesized to address implications. Ethical considerations and technological solutions to concerns about animal captivity are considered, with directions for future research with cetaceans and artificial alternatives included.

Introduction

"Diviner than the dolphin is nothing yet created"
Oppian of Silica Greece, 200 AD in McCulloch, 1998

Dolphin assisted therapy (DAT) originally emerged from the animal assisted therapy arena. However, unique psycho-physiological changes reported in humans following interaction with dolphins seems to set cetacean encounters apart therapeutically. Initially used and explained as a behaviour modification phenomenon, with principals imported from other successfully employed interventions functioning on a reward system, the strong desire to interact with dolphins prompted attention span increases in cognitively challenged individuals. Although still maturing, the research paradigm grew from the need to objectively investigate anecdotal reports of therapeutic gains instigated by dolphin interaction.

The unique cetacean characteristic, echolocative biosonar, dolphins' use of ultrasonic frequencies for echolocation (Birch,1997) are products of an evolutionary impetus for reliance on sound for communication as well as navigation. It may catalyse psychophysiological changes in humans and produce observed behavioural modification (Pinney, 1998). Psychophysiological effects of dolphin-human interaction can be considered a frequency mediated response in biological systems, dealing with potential methods of modifying human cerebral function through external stimuli characterised by their frequencies (Birch,1997). The possibilities of human-dolphin interaction have only been hinted at by research undertaken to date.

In a field with little empirical data, absence of standard criteria of what constitutes therapeutic progress (Limond, Bradshaw & Cormack, 1997), anecdotal results preceding organized research and generating scepticism and cynicism (Birch,1997), researchers are endeavouring to amalgamate interdisciplinary knowledge. By quantify the phenomenon they are refuting associations with mystical explanations and `New Age' sensibilities, an impediment to clarification of the phenomenon's mechanism (Martens, 1996).

Recognising the possibility of the entire field being dismissed as conjecture, or regarded as interchangeable with other forms of animal assisted therapy, David Cole's introduction of neurophysiological measures injected much needed credibility into the discipline. By collaborating with behaviourists, but incorporating this added dimension, Cole was able to speculate about mechanisms that may have instigated the behaviourists' success (AquaThought, 1997). The 1989 establishment of the AquaThought Foundation was a much needed milestone for the domain, in which isolated researchers acquired an interdisciplinary forum to propel the field towards objective investigation. Establishment of objective therapeutic merit was critical in ensuring that individuals who might benefit from such intervention were not precluded from gaining access to it (Martens, 1996).

Psychoneuroimmunological advances, and refinements in collection and interpretation of electroencephalogram (EEG) data have assisted researchers in investigating neurological changes that may be occurring during dolphin-human encounters. Replicating potentially beneficial effects of dolphin encounters through use of virtual reality (VR) systems and specialised signal rendering applications (McCulloch, 1998) is imminent.

Reflecting the balance between conjecture and empirical investigation that presently exists, the current review traces the emergence of the field, drawing from multi-disciplinary examples, in an attempt to clarify and synthesize possible underlying mechanisms. The chronology is not intended to imply a hierarchy of empirical importance, but illustrate the field's development, and demonstrate how the phenomenon operates on a variety of interdependent levels.

The behaviour modification perspective

When the mentally retarded brother of educational anthropologist Dr. Betsy Smith waded into the water with two adolescent dolphins in 1971 (Blow, 1998 in Philips, 1997), some therapeutic applications became immediately apparent. Nathanson (1980) formally launched the empirical aspect of the field by investigating physical and cognitive applications of dolphin assisted therapy for disabled children. Drawing on the attention deficit hypothesis to explain disabled individuals' learning and motivation difficulties, Nathanson suggested that some mentally retarded individuals' relative struggle to learn, is primarily a deficit in physiological attention to relevant dimensions of stimuli, rather than information processing inadequacy (Sokolov, 1963, Zeaman & House, 1963 in Nathanson, de Castro, Friend & McMahon, 1997). Nathanson reasoned that learning may be induced in these individuals by initial periods of extended exposure to relevant cues of stimuli, to elicit behaviour indicating that learning had occurred (Lewis & Harwitz, 1968, Moskowitz & Lohmann, 1970 in Nathanson et al., 1997). Identifying children's affinity for animals, Nathanson capitalised on it to capture their attention (Hypertek Features, undated). Research investigating humans bonding with animals and effects on development of processes such as speech, language and memory in the cognitively disabled population, supports Nathanson's rationale that animals appear to increase attention, and may be useful in enhancing cognitive processes (Nathanson, 1980, 1989). Significant behavioural improvements for emotionally or cognitively challenged individuals are widely reported from therapy involving domesticated animals (Limond et al., 1997). During pet facilitated therapy, autistic children's social interactions improved significantly and isolation behaviours decreased from baseline measures. Effects were weaker by follow up, but maintenance of effects is difficult in autistic therapy (Redefer & Goodman, 1989 in Limond et al., 1997). The interactions were insufficient to evoke improvements, and relied on therapists' orchestration of sessions to ensure success (Limond et al., 1997). Incorporating operant research findings suggesting that applied behaviour analysis and behaviour modification techniques are effective compared with other treatment models, in assisting individuals with serious disabilities (Miller, 1980, Foxx, 1982 in Nathanson et al., 1997), Nathanson formulated his protocol on the premise that attention span will increase as a result of desire to interact with dolphins. Nathanson's adroit selection of dolphins for animal assisted therapy occurred in an empirical climate of intense interest in cetacean cognitive abilities. Although cetacean intelligence, its extent and applications, are vehemently contested in both the popular and scientific literature, therapeutic applications of DAT originated in an empirical climate entranced by these possibilities, with research institutes including the United States Navy, toying with interspecies communication (LeVasseur, undated).[1] Cetaceans' learning style, closer to humans' multi-modal capacity, superior auditory discrimination, well developed short term memory, greater capacity to sustain interest in a task and vary behaviour, ensured a more effective attention holding animal with greater reinforcement potential (Nathanson et al., 1997). The cetaceans are used as a reward for desirable cognitive, physical or affective responses. The purpose of the program is motivational, with specific behaviours related to speech, language, gross and fine motor movement, development, rote or conceptual thinking. Children are required to perform tasks that challenge them in the area of their deficit. When a positive attempt or correct response is elicited, the child is rewarded by the dolphin encounter. Although regular, long term administration of DAT is not feasible, using dolphins in a motivational capacity instigates higher levels of functioning (McCulloch, 1998), complementing and reinforcing more conventional assistance (Nathanson, 1995). Upon resumption of regular therapy, this enhanced concentration allows for greater information processing and results in accelerated learning (McCulloch, 1998).

The original poolside research, undertaken in 1978, investigated two Down's syndrome subjects' ability to process and retain verbal information, using dolphins to present the stimuli and reinforce behaviour (Nathanson, 1980). Tasks were chosen to suit the individual subject's current cognitive capabilities. When the correct response was given, the child was allowed to feed the dolphin. This privilege did not occur with incorrect responses. Learning of stimuli occurred four times faster than in conventional educational settings, with a 15% improvement in information retention (Nathanson, 1980). Although extrapolation of these results was constrained by the small sample size, the insightful methodology of this pilot investigation provided potential for extending the design to other linguistic skills and with children presenting with various etiologies.

Although still contending with a less than ideal sample size, the replication of this work with six boys, over six months added to the knowledge base of DAT effects on speech and memory (Nathanson, 1989). Three subjects had Down's syndrome, one had hydrocephaly and severe developmental delays in all areas of functioning, one was brain damaged from meningitis contracted at three weeks of age and severe expressive aphasia, one was profoundly multiply handicapped due to an unspecified genetic anomaly, a seizure disorder, severely impaired motor skills and inability to speak. Ages ranged from 20 months to 10 years of age (Nathanson, 1989). Although the multiple etiologies of participants appears problematic in assessing potential effects of DAT, selection of a multiple baseline, across single subjects design circumvented pitfalls that statistical significance testing may have engendered in a study with more idiosyncratic subjects than the non-handicapped population. This design also allowed greater accuracy with the small sample size that the specialised research dictated. Each session consisted of thirty minutes of learning in a dolphin enhanced environment, and thirty minutes in a classroom situation. Novelty, prior learning and order effects were controlled. Appropriate reinforcement with the dolphin was selected for each subject and included feeding, touching swimming or kissing the dolphin. Although practise sessions controlled for novelty, effectiveness may have varied between children. Since novelty is less attractive for most disabled individuals than the security offered by familiarity, this was probably not an important confounder (Nathanson & de Faria, 1993). Dolphins were rewarded with food for correct behaviour. Speech production occurred less often in the classroom than during dolphin interaction. The dolphin situation elicited 1.4 to 19 times more correct speech than a classroom scenario, and 1.4 to 2.8% greater retention. More speech production was found for the Down's syndrome and multiply handicapped subjects, with one of the former responding correctly 38% of the time in the presence of dolphins and only 4% in the classroom. Expectations for all 6 children, in rate and accuracy of speech production, were exceeded (Nathanson, 1989).

Since immersion in water moderates anxiety, reestablishes cognitive and sensory motor perceptual patterns, provides kinesthetic feedback, and relieves pain (Nathanson et al., 1997), Nathanson's 1993 investigation with 8 children, aged 3-8 years, endeavoured to establish if the cognitive improvements of the previous studies could be replicated in an aquatic environment without dolphins as primary reinforcement. Advances were noted using a favourite toy as reinforcement, however progress was not as dramatic as when a dolphin was present. Nathanson speculated that interaction with dolphins may be so powerful and pleasurable that few, if any other settings match the level of meaningfulness for the children (Nathanson & de Faria, 1993). In a population in which maximum enthusiasm is required for improvement, higher motivational levels are desirable. This was realised when dolphins, but not favourite toys, were part of the reinforcement (Nathanson & de Faria, 1993).

Recognizing the need to justify the use of exotic animals in therapeutic applications, Nathanson (1997) attempted to contrast the effects of 2 weeks of dolphin assisted therapy with 6 months of conventional speech language and physical therapy. To determine if DAT could contend with, or outperform conventional therapy, a sample of 47 2-13 year old children with various severe neuropsychological deficits were monitored. Despite the great expenditure involved in DAT it was found to be cost efficient, with quantifiable results ocurring much faster and at considerably less cost than longer term, conventional physical and speech/language therapy (Nathanson et al., 1997).

A 15 item closed form parent questionnaire (n=71) analysed long term effects of gains achieved by DAT (Nathanson, in press). Maintenance or improvement of skills obtained in the DAT program was found in 50% of cases, 12 months after conclusion of treatment. Two weeks of DAT had better longitudinal ramifications than 1 week of learning while interacting with dolphins. The maintenance of effects was not found to be influenced by patients' etiologies (Nathanson, in press).

The protocols devised in the aforementioned investigations, formed the basis for 10,000 clinical sessions conducted between 1988 and 1996 on 700 children, with 35 diagnoses, from 22 countries and 37 states of America (Nathanson et al., 1997). In addition to the pathologies addressed by the empirical investigations, the DAT facility accepted patients with cerebral palsy, autism, Angelman's syndrome, Cri-du chat, and brain and spinal chord pathologies induced by trauma (Dolphin

Human Therapy, undated). Most patients presented with several conditions (Nathanson, 1996).

Differing from other pathologies investigated (Nathanson et al., 1997), autistic sufferers appear to require daily reinforcement with dolphins. They seem to gain enjoyment, but not measurable improvements from the experience. However, there are anecdotal reports of dolphin elicited improvements in autistics that refute this observation (McCulloch, 1998). It is in the present author's opinion that this finding requires further verification before autistic patients are included in costly therapeutic endeavours, or erroneously excluded from assistance that may prove useful.

In review of Nathanson's steady progression of research, some shortcomings and future directions become apparent. The inclusion of all clinical populations in the studies does not address whether the improvements in learning are restricted to these children, or would also be experienced by healthy children taught with cetacean assistance. Also not addressed to date is whether adults with cognitive pathologies could benefit from this intervention. The great age range included in the trials, reflecting different stages of development, is particularly problematic in cognitively challenged samples. As is the use of etiologically heterogenous samples. These factors, though challenging to avoid in specialised research, combine to obscure the emergence of unequivocal trends. Since animal presence in general facilitates pro-social behaviour (Limond et al., 1997), but anecdotally, parents of DAT participants report dramatically greater improvements in language and motor skills following dolphin encounters than interaction with pets or other animals (Nathanson & de Faria, 1993), objectively contrasting the efficacy of DAT with domestic animal interaction may be appropriate. Although speech and memory are reliably used as quantifiable measures of cognition for retarded individuals (Mittler & deJong, 1977 in Nathanson, 1989), including other measures of cognition, as well as creativity and proprioceptive skills may be instructive.

Advocates of extending applications of DAT beyond the handicapped population, consider 'at risk' juvenile offenders possible candidates for interacting with dolphins therapeutically (Sebastiani, 1996). Examining behavioural and affective modification in the framework of Nathanson's attention deficit theory, may lend support to their contention.

In a preliminary study addressing other aspects of handicapped children's quality of life, interaction between parents and their children with disabilities, in the presence of the unique stimulus of dolphin interaction was monitored(Lindeblad, 1996). Recognizing that emotional bonds are essential to psychological growth, and that the psychological strain of caring for disabled children may prevent the carefree play conducive to bond formation, this situation was designed to optimise meaningful interactions for these families. Behaviours such as eye contact, touching and verbal interaction were quantified for the families of the 3 to 9 year old children, as they interacted with the dolphins. The initiator of contact was also noted in a case study design. A minimum of 3 sessions was found to foster camaraderie, longer and more equal verbal exchange, greater incidence of physical touch and improved relationships at home, as reported by parents (Lindeblad, 1996). Further investigations, including quantification of parental attitudes concerning the experience and communication with their child are envisioned.

Three autistic and 4 emotionally challenged children were evaluated before and after interacting with dolphins in Panama City (The Human Dolphin Institute, 1997). Cognitive abilities and concentration span improved. EEG data is yet to be analysed. Improvements in children presenting with autism, attention deficit disorder (ADD) and Chronic Fatigue Syndrome have also been noted at this facility (The Human Dolphin Institute, 1997).

Findings of dolphin assisted improvements with cognitive deficits affecting attention led to hypotheses that Post Traumatic Stress Disorder (PTSD) affected children, who also suffer from disruption in attention, communication reluctance, as well as poor interpersonal interactions, may benefit from DAT. Monitoring neurological and behavioural changes over a 6 month program of DAT as well as differences in symptoms of aggression, concentration difficulty, nightmares, depression and anxiety at home, school and play (Schofield, 1997a) was proposed. An array of neuropsychological measures will be conducted on 7 to 10 year old children with a DSM-IV diagnosis of PTSD (Schofield, 1997b).

Most research involves relatively short term involvement with a DAT program. Long term therapy is addressed at the Dolphin Reef facility in

Eilat, Israel, with a year long program devised for individual patients presenting with Down's syndrome, anorexia nervosa, cancer, depression, autism, PTSD and dyslexia (Schwer, 1996). Half the session involves conditional work on a platform with a trainer, while the remainder of the session is spent in the water with the onus to interact, on the dolphin. Echoing Nathanson's operant conditioning model, the therapeutic poolside task, which may include food preparation, feeding or husbandry, engages the participant, while the prospect of interaction serves as motivation. A 12 week documentation of the procedure identified improvements in participants' confidence and self esteem (Klingel, 1996). More thorough analysis of results would make the findings of this facility a useful adjunct to the knowledge based acquired by Nathanson.

In Japan, a psychologically based empirical investigation into human responses to dolphin exposure has been conducted. Psychological states before and after dolphin encounters in 90 healthy subjects were analysed through semantic differential evaluation of artwork. This was deemed a good marker for stress evaluation. A marked reduction was observed in the dolphin interaction participants, in contrast to a control group who watched dolphins, but showed no significant changes in artwork. The investigators attributed the change to decreased anxiety engendered by the dolphin encounter (Fujii, Ukiyo & Aoki, 1996). It may have been instructive to include water immersion effect trials. Although the research was undertaken in accordance with standard scientific protocol, and has an impressive sample size, the measure of drawing interpretations as an indicator of stress levels may not be regarded as the most appropriate. Although valid, it lacks the repute that more established psychological measures may have lent to the investigation. In a field already vying for scientific recognition, this measure may not have been the most astute choice.

In the Ukraine, former Soviet Navy cetaceans have assisted in therapy with 1500 doctor referred patients. Although fraught with methodological concerns, this research facility has found a 60% improvement in childhood phobias and stuttering, and a 30% success rate with infantile cerebral palsy. Mood enhancement and functional capacity gains were also found. Comparisons in cardiac monitoring before and after each of seven to ten sessions are yet to be analysed (Lukina, 1996). It is unfortunate that a more thorough research protocol has not been used with access to such a large sample.

Although much important data has been collected in a clinical setting, it may be problematic to rely on results of individuals who volitionally present at these facilities for treatment. The great financial and emotional expenditure invested by these families may of itself provide an impetus to improve. Although the data collected spans several cultures and lends support to a universal phenomenon, discrepancies in the methods used with captive dolphin programs prevents a cohesive approach to DAT from being realised.

The psychoneuroimmunological perspective

Although not involved in empirical investigations, Dr Horace Dobbs is another pioneering force in popularizing psychologically therapeutic effects of dolphin interaction. His original well documented success (Dobbs,1990) focussed on alleviating chronic depression with this intervention, and has also chronicled improvements in anorexia nervosa (Parker, 1993) and other psychiatric maladies. His inability to explain the mechanism doesn't perturb him. His consternation lies in recognising the many candidates who would benefit from a dolphin encounter, yet are unable to experience it. He attributes the improvements to classic psychoneuroimmunological doctrine purporting that physical complaints, instigated by psychological processes, can be reversed by psychogenic mediators. He postulates that this could also be stimulated by dolphin images and sounds (Whale-Watching-Web, undated). In his view, live dolphin presence is not crucial for healing to occur (The Virtual Dolphin Project, 1998). Although his early work was with wild dolphins, in his aim to assist more patients, Dobbs now believes that the self-reported transformational experiences that dolphins instigated in patients, can be recreated. He has attempted to capture the mood altering effects of dolphins by producing a recording, including music and dolphin sounds. Responses to a self report questionnaire revealed 75% of listeners experienced affective improvements (Parker, 1993). Dobbs aspires to eventually recreate the dolphin encounter experience more realistically by projecting cetacean holograms into a warm water tank (The Virtual Dolphin Project, 1998), in which participants are submerged. By including sensory elements of the dolphin experience such as sonic, visual and tactile, he hopes to study effects on neurologically and developmentally delayed children (The Virtual Dolphin Project, 1998).

Neurophysiological explanations

Although overt behavioural and affective ramifications of dolphin human interaction have been documented for over two decades, researchers lamented ever identifying causative factors of the phenomenon (AquaThought Foundation, 1997). The establishment of the AquaThought Foundation, an organisation with intentions of physiologically quantifying reported effects of dolphin interaction on humans, instigated renewed interest in pursuing these efforts. Understanding how and why dolphins catalyse behaviour modification in humans, and electronically reproducing these effects for widespread distribution are goals of the foundation (AquaThought Foundation, 1997). By examining frequency mediated effects of biological systems, events occurring at a particular level of biological organization, may reveal ramifications on other levels, with observable behavioural effects instigated by combinations of molecular events (Birch,1997). Far from discounting the importance of psychological findings, this model augments them by identifying underlying psychophysiological mechanisms.

A 16 channel EEG system, featuring 2 and 3 dimensional topographic visualisation, neurometric analysis, phase coherence analysis and compressed spectral array visualisation, was devised for this research and is currently undergoing field testing (AquaThought Foundation, 1997). Applying propriety processes for extracting algorithms for automatic correlation between EEG output characteristics and biophysical events is also under investigation (AquaThought Foundation, 1997). In attempting to develop a methodology to automate the recognition of complex EEG patterns related to dolphin interaction (AquaThought Foundation, 1997), AquaThought is compiling a normalization set database for a back-propagating neural network (AquaThought Foundation, 1997). The

AquaThought protocol involves recording baseline and post interaction EEG, blood pressure and temperature, and completing a simple psychological inventory. Forty subjects have been analysed using these measures. Emerging trends are decreases in dominant frequency following dolphin interaction, and a period of hemispheric synchronisation, defined as in-phase left and right hemisphere output with a similar frequency, and more evenly distributed background EEG within the spectrum (Cole, 1996). Proposed additions involve including a water immersion baseline comparison for each subject data set (AquaThought Foundation, 1997). The current author suggests that analysing the duration that these effects are sustained may be of interest in discerning therapeutic parameters.

Cole (1996) speculated how this neurological data may correlate with reported therapeutic benefits. The increased alpha-theta waves observed in dolphin-human interaction encounters have also been shown to improve learning in other contexts (Wallace, 1989; Birch,1996). The alpha state induction may be responsible for human immune system modulation, as psychoneuroimmunological doctrine maintains. This addresses successful anecdotal cancer outcomes, however many instances of therapeutic benefit are not accounted for by this model. (Cole, 1996).

Recording ambient echolocative intensities during dolphin presence has been undertaken (AquaThought, 1997). If shown to consistently and predictably correlate with deviation from baseline EEG, psycho-physiological changes may be explainable (Cole,1995,1996). Acoustics are propagated as longitudinal pressure waves through the transmitting medium in which they are generated. Ultrasound consists of such vibrations which have a frequency exceeding the upper frequency limit for human hearing identified as 10-20Khz (Blitz, 1963 in Birch,1997).

Cole (1996) speculated that neurotransmitter production and uptake cycles may be altered during dolphin encounters, accounting for ubiquitous endocrinological effects. This could be the result of sono-chemical changes occurring at synapses (Cole, 1996). Sonophoresis, the interaction of sound with matter through cavitation (Cole, 1996), resulting from the dolphins biosonar output, may explain observed, chemical and electrical cerebral changes. Cavitation occurs when gaseous 100 micron diameter voids are created by alternating regions of compression and expansion, and forced into oscillations, resulting in generation of mechanical shear stresses, which disrupt biological material (Suslick, 1989; Cole, 1996; Williams, 1983 in Birch,1997). Cavitation induced sonophoresis enhances transport of permeates, including hormones, through cell membranes (Cole, 1996), by altering membrane potentials of post synaptic terminals, and influencing influx of sodium and calcium ions and efflux of potassium ions. Altered post-synaptic potential cycles would be observed through scalp electrodes as variations in EEG signals (Cole, 1996).

Ultrasonic cavitation's physiological effects have been demonstrated to include, erythrocytes forming more agglutinated blood clotting action preceded by loss of charge on cell walls caused by cavitation (Pohl, Pohl & Millner, 1995 in Cole, 1996), acceleration of thrombolyisis, the disruption of adhering platelets, occurring with intensities of .5W/cm^2 (Tachibana & Tachibana, 1995 in Cole, 1996),disruption of leukemia Ll210 cell membranes (Kessel, Fowlkes & Cain, 1994 in Cole, 1996), cell lysis, the membrane disintegration and cytoplasmic leakage instigated by intensities of 2.5W/cm^2. This has prompted suggestions of possible applications of ultrasound in cancer treatment (Jeffers et al., 1995 in Cole, 1996). Cavitation could stimulate T cell production and be responsible for release of endorphins (Hypertek Features, undated). This model explains pain alleviating effects of dolphin interactions, demonstrated by greater maternal relaxation in human mothers during waterbirths (Charkovsky, undated in Birch,1996), and spinal fusion patients' increased plasma hormones after dolphin interaction (Smart, 1998). To implicate the sonophoresis model in observed dolphin interaction induced variations in human EEG, examining dolphin biosonar signal intensity is necessary. A floating hydrophone and waterproofed signal analysis telemetry unit allowed monitoring of open water interaction to investigate associations between dolphins' acoustic emissions and human EEG modifications (Birch,1995b). Atlantic bottlenose dolphins (Tursiops truncatus), most often used in DAT, are capable of producing 23dB of echolocative sound intensities in captivity, the equivalent of 1µPa/metre. To contrast this value against medical ultrasonography levels known to produce sonophoresis, the convertion to watts per square centimetre, 8.3w/cm^2, must be evaluated (Cole, 1996). This intensity indicates that dolphins' biosonar is capable of inducing cell membrane cavitation, resulting in sonophpresis (Cole, 1996). As well as intensity, field coupling is central in delivering sufficient ultrasound to induce cavitation. Medically therapeutic ultrasound transducers directly contact somatic target areas. Dolphin echolocative sonar is transmitted through water, a medium 60 times more conducive to sound transference than air. Within a salt water medium, impedance is practically non-existent (Cole, 1996).

Also investigating EEG as indicative of neuro-electrical and neuro-chemical change, Birch (1997) contests Cole's sonophoresis model as the primary instigator of dolphin interaction induced human endocrine modifications. Therapeutic transducers induce cavitation at intensities of $2W/cm^2$ (Mitragori et al., 1995 in Cole, 1996), with ultrasonically induced bioeffects not observed below a spatial-peak, temporal average intensity of $100mW/cm^2$. In the case of proximal spinal and cranial stimulation, with dolphins producing over 220dB, ultrasonic intensities exceeding this standard are achieved, and the cavitational model may apply. However, ultrasonic intensity levels affecting subjects interacting with cetaceans at a distance are well below this standard, and make it unlikely that cavitational effects are responsible for Birch's empirical open water findings. Behavioural and electrophysiological changes observed in subjects exposed to less intimate dolphin contact, when ultrasonic intensities may not meet the required level, suggest other mechanisms may be involved (Birch,1997). The effects of field coupling in delivering sufficient ultrasonic energy to induce cavitation require further investigation.

Sound may induce biological changes in vivo through sonochemical cavitation in the instance of dolphins ultrasonics, or more subtly through resonant entrainment, a phenomenon of external rhythms influencing living organisms' cycles (Playfair & Hill, 1978 in Birch,1997). In situations of less powerful dolphin emissions, or less intimate interspecies contact (Holmes Atwater, 1996), this model may apply. Brainwave entrainment appears to be a significant example of frequency mediated effects on biological systems with further potential of having quantifiable effects on hormonal response in-vivo (Birch,1997). In addition to low frequency acoustic emissions, bottlenose dolphins also produce low frequency electromagnetic and scalar components (Rollins & Byrd 1995 in Birch, 1997). The magnetic and electric fields may be a function of the piezoelectric substance forming the echolocation shaping material in dolphins' melon structure (Byrd, 1998). Task specific sensors have simultaneously recorded ambient acoustic, electrical, electrostatic and magnetic signals (Birch,1997). Concurrent magnetic, acoustic and electric signals near 16 Hz were recorded in over 70% of all data runs (Byrd,1995) during interactions with 8 healthy children. Several EEG recordings indicated a shift in predominant frequency to approximately 16 Hz after interaction (Byrd,1995). Some frequencies existed acoustically and not magnetically or electrically, and some frequencies existed when acoustic and electric did not. Several were common to all 3 frequencies of 12Hz, 16Hz and 26 Hz. High frequency information is yet to be analysed (Byrd,1995).

Birch proposed that the ELF vibrations stimulate electrophysiological and behavioural changes observed in subjects through a Pro-opiomelanocortin (POMC)neurochemical mechanism in the 10-50Hz range (Birch,1997). In certain individuals, the pineal gland, an endo-crinological orchestrator, has been found to be EMF sensitive. To illustrate potential external EMF interactions with hormonal systems, Birch discusses associations between EMF altered pineal melatonin synthesis through induced current effects (Wilson, 1988 in Birch,1997) and associations with depressive disorders caused by this disruption.

Birch also addressed reported transformational experiences elicited by dolphin interaction, usually discounted by objective investigators due to lack of informational content. Temporal lobe illumination with low intensity and frequency magnetic fields may catalyse states of con-sciousness characteristic of transformational or mystical experiences, with content dependent on cuing stimuli presented. Transcranial Electromag-netic Stimulation (TMS) involves application of pulsed magnetic fields to the brain, with this magnetic stimulation capable of temporarily activating or paralysing various cerebral areas (Concar, 1995 in Birch,1997). Birch discusses Persinger's (1983) discovery that low intensity transcranial electromagnetic stimulation instigates these episodes. This temporal lobe transient (TLT) hypothesis postulates that mystical experiences are evoked by electrical microseizuring deep within temporal lobe structures, with correlates of these microseizures measur-able at a cortical level (Birch,1997). The actual significant experience is evoked by a transient, focal electrical display within the temporal lobe, of several seconds duration. These TLT's are considered analogous to electrical microseizures, with altered facial expressions the only obvious motor component (Birch,1997). The resultant hemispheric synchronisation is conducive to altered perceptions (Birch,1996). Frequencies of observed dolphin EM emission fall within the range required for these experiences. If coincident with endorphin self reward effects, the reported sustained, positive transformational effects of dolphin encounters become plausible (Birch,1996). Considered potent modifiers of human behaviour, a single episode in the correct context may precede longitudinal behaviour modification (Persinger, 1983 in Birch,1997). This hypothesis is an interesting framework in which to examine claims of dolphin assisted therapy, particularly Dobbs' (1990) experiences with depressives. Although able to replicate some therapeutic benefits through recorded dolphin sounds, and attributing these anecdotal improvements to psychoneuroimmunological effects, Dobbs may be mistaken in purporting that live dolphins are unnecessary for the sustained effects experienced by his initial patients through dolphin induced transformational experiences, possibly instigated by generation of TLT's in their cortexes (Birch,1997).

The TLT phenomena appears to parallel POMC derived microseizuring patterns. It is therefore plausible that TLT enhancement, through TMS may result in brain activity resembling POMC hormone microseizuring patterns. It follows that such similarities may elicit comparative behavioural effects (Birch,1997). Increases in endorphin and ACTH concentrates would elicit cortical microseizuring activity parallelling Persinger's TLT mechanism. Since biosonar induced mechanical vibration may also increase POMC derived hormone release, and neural vibration, a whole body entrainment, may influence hormone synthesis and release as well, evidence of dolphin interaction induced EEG modification are not surprising. Such changes in brain activity are considered to be observed in EEG recordings as frequency decreases and amplitude increases.

While these TLT like phenomena could potentiate transformational experiences reported for dolphin interaction experiences, neurophysiological effects of vibration also increase concentrations of analgesic neurochemicals (Birch,1997), achievable from dolphins' EMF range of 16-26Hz (Rollins & Byrd 1995 in Birch, 1997). Endorphin and ACTH release may potentiate observed analgesic and cognitive effects. ACTH involvement in nerve regeneration may also contribute to cognitive improvements observed in subjects. Additionally the reward mechanism provided by endorphins would allow for positive affective responses, which may also improve learning capabilities. The endorphin reward can also result in behavioural changes, parallelling EMF induced transformational states, and alleviate depression (Birch,1997).

POMC precursor molecules can be cleaved to produce ACTH. When administered to autistic children, synthetic ACTH analogues improved social interaction duration and intensity (Birch,1996). If synchronous with endorphin release, ACTH secretion could provide an additional hormonal mechanism for observed improvements in cognitively challenged children (Birch,1996). In a study of effects of addictive substances on EEG patterns, opiates were found to induce synchronous left and right slow wave activity. Such evidence highlights associations between neurochemical concentration and EEG modification. Consequently EEG traces from subjects exhibiting increased in slow wave activity were considered as putative indicators of modified endorphin/POMC expression in vivo (Birch,1996).

These proposed mechanisms encompass distal interaction, resulting in psychophysiological changes. The instances of direct cranial and spinal exposure can also be accounted for by these processes, however the cavitation and sonophoresis hypothesis should not be discounted for these direct contacts (Birch,1997). This may be best evaluated with trained, captive dolphins (Birch,1997).

The Resonant Recognition Model (RRM) proposes that proteins are activated by characteristic resonant frequencies which can be calculated within the model. If biosonar signals and human behaviour correlate consistently, it may be possible to link the proposed biomolecular changes in endorphin levels with the predictive capabilities of the RRM (Birch,1995a). Therapeutic applications of predicting and generating acoustic frequencies, with stimulating effects on specific proteins, and by extension mental and general health status (Birch,1996), are plausible.

Participants in Birch's investigations were wild dolphin swim excursion patrons. Screening, or exclusion based on EEG recordings was not conducted. The impetus to interact was on the dolphins, resulting in interaction variability, a pitfall of research involving untamed animals

(Birch,1997). Ambient acoustic signals were recorded, and water immersion control experiments were conducted (Birch,1997). Eighty five percent of subjects displayed noticeable EEG changes, characterised by frequency decreases and amplitude increases, with demonstration of hemispheric synchronisation (Birch,1997), corroborating AquaThought's knowledge base. In this study, release of POMC derivatives (including ACTH and endorphins) were inferred from presence of increased slow waves, greater amplitude and intra-hemispheric synchronisation (Birch,1997) of EEG. Visual only interactions, in which biosonar was not detected, resulted in no changes in EEG patterns from baseline recordings, while auditory only interactions resulted in similar changes to visual and auditory interchanges. This tentatively supports involvement of a sonic mechanism in cerebral activity alteration. Given that discerning auditory only interactions are dependent on dolphin activity and water clarity, it is difficult to generate these conditions for a more controlled investigation. It may be explored further in tank based situations using artificial ultrasound projectors (Birch,1997). Depth sounder exposure or simple immersion produced no discernable changes in EEG (Birch,1997). The Dolphin Virtual Reality Telepresence (DVRT) System, a prototype of virtual reality based information presentation applied to dolphin therapy, was used with ten participants to investigate whether visual perception of dolphins could induce similar EEG changes as wild dolphin contact (Birch,1997). Although self reported increases in relaxation were found, no EEG changes were identified as with actual dolphin encounters (Birch,1997).

The foray into neurophysiological investigation of DAT, has prompted researchers to incorporate them into psychologically based evaluations. In addition to Nathanson, De Bergerac (1998) is active in this endeavour, and is addressing DAT effects on emotional and physical pathologies (The Dolphin Society, 1998), with a view to investigating differences in response of sufferers of various ailments. A pilot program found EEG changes, improvements in affect, ability to moderate stress, weight loss, decreased consumption of alcohol and tobacco, and increased self care incentives, including dietary improvement. (The Dolphin Society, 1998). Phobias, especially for aquatic phenomena have also been addressed (The Dolphin Society, 1998).

Cetacean biosonar

Both audible and ultrasonic emissions are used by cetaceans. Pulsed sounds are clicks, burst pulses are click trains, chirps and chuckles, and un-pulsed sounds are whistles and squeaks (Birch,1997). Pulsed sounds are broadband signals of sort duration. Ultrasound returning echoes, generated by the pulses allow the dolphin to construct an acoustic image of objects, identifying size, shape and orientation (Birch,1997). Clicks are emitted at intervals of 19-45 milliseconds. Longer than the two-way transit time, this lag allows processing of returning echo data (Au, 1993, Evans, 1994 in Birch,1997). Spectral modification of the signal, deliberate variation of signals to match specific targets (Au, 1993 in Birch,1997), has not been observed, casting doubt on claims that dolphins purposefully direct their biosonar therapeutically when interacting with ailing humans (Birch,1997). However, subjects held in a dorsal floating position during interactions have prompted dolphins to approach, unsolicited by trainers, and position themselves so as to place their melon, the source of their sonic mechanism, behind the skull of the subject and echolocate directly into their occipital lobes (Birch, 1997).

Ultrasound use in a liquid medium, and the highly aqueous nature of biological systems, produces effective coupling between bodies immersed in water and ultrasonic signals. Different absorption and reflection characteristics of various body tissues allows for imaging processes to occur. When using their biosonar, dolphins theoretically detect denser bone structure and reflections from air spaces as part of ultrasonic images of humans encountered. Widespread medical ultrasound use for foetal monitoring, and noninvasive imaging of viscera, is the medical counterpart of this process (Marguerее, 1991 in Birch,1997). Perhaps curiosity instigates this echolocative behaviour. Ultrasonic reflections from human bone structure may be of some inexplicable interest to the dolphins. This curiosity appears limited to biological systems, as this behaviour is not engaged in with other reflective surfaces such as concrete tank walls (Birch,1997).

During a program in which captive dolphins were trained to emit sonar to ailing areas of participants' bodies, usually obedient dolphins were occasionally observed refusing trainers' directions and moving to other body parts. Further medical evaluations in each of these instances revealed initial diagnostic errors in favour of the dolphins' `second opinions' (Price, 1998). Ninety percent of the clinical population of this facility improved significantly (Price, 1998). Although dolphins' aptitude for discrimination between objects and their ability to acquire images of internal structures is known (Holmes Atwater, 1996), closer inspection of this phenomenon is required.

Dolphins may also detect electromagnetic fields from humans and attempt to communicate using the same frequencies in the human brainwave band of 6-30Hz. This speculation is based on alteration of human brainwave frequencies to conform with the fields recorded from dolphins during human interaction (Byrd,1995). It has been suggested that when individuals with pathologies interact with dolphins, emissions of biosonar are not inspired by benevolence, but by attempts to alleviate the distress that these abnormal frequencies cause the cetaceans (Hall, 1998).

Dolphins may use intense bursts of sound to immobilise or kill prey, indicating some awareness on dolphins' part, of possible bioeffects of their sonar (Birch,1997). Such a mechanism has not been observed with captive dolphins since signals are reflected back to the sender off tank walls (Birch,1997). Their diet of dead fish does not require this predatory behaviour.

Dolphins using sonar will refrain from transmitting in the proximity of another cetacean. Recordings of feeding dolphins producing loud, low frequency sounds bangs lasting 200 microseconds, up to 100 times longer than the trains of echolocating clicks which precede them (Anderson, 1997 in Birch,1997), illustrates the possibility of cetaceans being aware of, or having instinctual understanding of the impact of their sonic emissions on other creatures (Birch,1997).

Ethical responsibilities

"The dolphin's smile is nature's greatest deception"

Riley & Faulkner, 1993

Irrespective of noble therapeutic ideals, animal captivity has its critics (Hypertek Features, undated). Captive dolphins' 5.4 year lifespan contrasts markedly to their wild counterparts' 45 (White, 1990) to 55 years (Dolphin Project International, undated a). Cetaceans in captivity suffer stress, behavioural abnormalities, high mortalities, and breeding problems (Birch,1997).Truly miserable dolphins will become non-communicative or highly aggressive (Riley & Faulkner, 1993). Incidents involving humans sustaining bruises, broken bones and hospitalisations from captive dolphins (Dolphin Project International, undated a) have been reported.

Hydrotherapy success without dolphins and improvements elicited by domesticated animals have been cited as alternatives to captive dolphin programs. However findings that interaction with dolphins is optimum for cognitive improvements in humans with disabilities (Nathanson et al., 1997) and other pathologies, ensures the continuation of this practice. The therapeutic mechanism is not understood well enough for artificial replication (AquaThought Foundation, 1998) as yet. Tursiops production of over 8.2 watts/cm^2 of sound pressure in the ultrasonic range would require transducers used for ultrasonic soldering of metals, which cannot be safely done at present (AquaThought Foundation, 1998). However no instance of detrimental reactions to DAT has been recorded (AquaThought, 1998).

Most facilities attempt to minimise stress of captivity (AquaThought Foundation, 1998), focussing on equalised enrichment of clients and dolphins. Nathanson reflects the outlook of most of his peers in emphasizing cetacean wellbeing over therapeutic endeavours and financial or empirical gain. He emphasises selecting appropriate dolphin candidates for children. Clinical experience reveals considerable variability between tursiops' interest in humans (Nathanson & de Faria, 1993) and aptitude for therapeutic assistance. Interdisciplinary knowledge is required to make an adroit selection (Giannobile,1996).

During research at Nathanson's facilities (1992, 1988), fences were below water level at high tide. Dolphins remained voluntarily and their stress levels were observed to decline following controlled interaction with humans (Nathanson, 1989). It would be pertinent to quantify this anecdotal observation. Dolphin Reef in Israel has similar facilities which allow the dolphins an open water sojourn. Preference for wild dolphin interaction research is emerging. To date adherence to ecological guidelines have been maintained. This must be safeguarded if prevalence of this therapeutic field increases.

Possibility of disease transmission during DAT has generated concerns. Previously, this focussed on zoonotic disease, but now encompasses possibilities of human to dolphin transmission (Dolphin Project International, undated a). Evaluation of evolutionary based host specificity of most infectious organisms has discounted this threat (Bossart, 1996).

Acoustic measurements derived from captive dolphins in tanks range from 30-60hz. In contrast, the same species uses higher intensity signals, with higher peak frequencies in open waters . In oceanariums, cetacean use of sonar is curtailed because signals bounce off tank walls (Dolphin Project International, undated b). Psychological effects of this constraint have been likened to imprisoning sight oriented organisms in an enclosure of mirrors (Dolphin Project International, undated b). Reluctance to use sonar (Smith, 1971 in Blow, 1998) must be considered if echolocative mechanisms are under empirical scrutiny. Findings that rehabilitated captive dolphins must relearn to echolocate living and moving organisms for food emphasises this difference (Reinartz, 1998). A wild dolphin interaction paradigm may be more suited for these empirical pursuits.

The present author questions if DAT is the most appropriate term to define this interspecies collaboration. It connotes that humans are the only beneficiary of this relationship, and that dolphins are a commodity to be exploited for this end. Perhaps Dolphin and Human Interaction Therapy (DHIT) may reflect greater interspecies respect, and greater commitment to research benefiting both species than the current choice.

Progress in understanding ultrasound production and effects for human advantage, including modelling artificial neural networks on cetaceans' active sonar target detection and recognition system

(Moore, undated), may ultimately be beneficial for cetaceans. Studies have shown icebreaker noise masks cetaceans' signals to the point of incomprehensibility, having fatal results. Masking interfering signals to prevent infringing on cetacean communication may now be possible (Erbe, 1997). Given their involvement in therapeutic endeavours, it seems fitting to apply understanding of ultrasonic properties to enhance cetaceans' existence. This has been implemented in attempts to deter dolphins from approaching tuna nets , in which great numbers ultimately drown.

Virtual dolphins

With goals to develop an immersive platform for realistic simulation of dolphin interaction, VR technology may provide opportunities for widespread experience of the phenomenon. It may eventually obviate the need for captive dolphins, and prevent exploitation of known wild dolphin haunts, if therapeutic applications are popularised (Blow, 1998). However this possibility exists on the premise that the reproduction is intense and realistic enough.

This trajectory of investigation may potentially advance evoked potential neurological diagnostics through development of protocols for cognitive neuronal feedback, delivered within a virtual reality system (AquaThought Foundation, 1997).

As a research tool in telepresence interaction with dolphins, designed to remotely extend the sensory modalities of users into an underwater dolphin environment, with the simulator platform coupling to visual auditory and nervous sensory systems (AquaThought Foundation, 1997), DVRT was designed to verify experimentally that the neurological phenomena found to accompany dolphin interaction are attributable to sensory stimulation during interaction (AquaThought Foundation, 1997). Commercially available *CyberFin,* which transports participants into an underwater sanctuary populated by dolphins (AquaThought Foundation, 1997), and other VR endeavours have not yet accomplished this aim with healthy subjects within the parameters examined. Anecdotal reports of success with cognitively impaired subjects are yet to be substantiated (Birch, 1998).

Tools under investigation include the neurophone, employed to simulate sensations of acoustic energy perceived while encountering echolocating dolphins. It is a device with direct linkage to the human nervous system through EMF transduction (AquaThought Foundation, 1997) of incoming stereo hydrophone audio signals directly onto participants' neuronal pathways. The audio signal fed into the neurophone can be perceived by its user without apparent external audio signals being present. This form of direct sensory input reproduces mechanical skin to water coupling occurring during dolphin encounters (AquaThought Foundation, 1997). Although subjected to several investigations, the exact method of operation of the neurophone, invented by Patrick Flannagan in 1962 as a hearing aid, is still unclear (AquaThought Foundation, 1997). For DVRT, primary applications for neurophone technology are accurate reproductions of skin to water coupled transduction of biosonar energy (AquaThought Foundation, 1997). Also used in *CyberFin* is the Vibrasonic ACV-8000, a Total Sensory Stimulation device consisting of a liquid crystal filled platform that emulates sensations of floating in an aqueous medium.

Directions with dolphins

Birch looks to cost effective, ecologically sound substitutes for DAT, including refinements of DVRT to induce the electrophysiological changes observed following dolphin interaction, involving nervous system excitation through electro magnetic stimulation. Integrating DVRT with Persinger's TMS methodology may elicit the tranformational states conducive to depression alleviation. Use of magnetic fields for these purposes will require prior safety evaluation (Birch, 1997). DVRT use in veterans of prior live dolphin interactions, may elicit similar neuropsychological responses to the latter, while individuals without previous exposure to live dolphins may not exhibit any neurophysiological changes (Birch, 1998). Dobbs' psychoneuroimmunological model is testable through this hypothesis.

Pulsed ultrasound generators could be used to artificially reproduce biosonar. Monitoring psychophysiological responses to this stimuli would assist in clarification of the mechanism and provide a useful alternative to DAT. To determine characteristics of the required signals, preliminary tank based interactions between captive dolphins and humans would be required. This would also allow monitoring of sonochemical effects on endocrinological disorders. It is possible that enhanced transportation of permeates across cellular membranes induced by sonophoresis may assist disorders in which resistance to endogenous hormones is involved.

Nathanson has proposed assessing DAT with deaf and blind participants (Nathanson, 1989). The potential for sensory research with these populations, as well as refinement of neurophone technology with the former, makes these fruitful avenues for exploration.

The present author suggests more contrasts between wild and captive dolphin exposure, inclusion of healthy control subjects in more studies and comparisons between DAT and other animal assisted therapy. Since several mechanisms are under investigations, clear therapeutic aims would enable more adroit selection of methodology. The possibility that isolating these mechanisms may attenuate the therapeutic benefits must not be overlooked.

Conclusion

Although humans are in the preliminary stages of understanding the effects of sharing close encounters with dolphins (AquaThought Foundation, 1998), outright dismissal of the phenomenon as unfounded is no longer possible. The emerging alliance dedicated to exploration of dolphin-human interaction through neurophysiological technology is rectifying the paucity of objective verification of these assertions and reliance on subjective measures. In traditional animal assisted therapy paradigms, animals are considered catalysts, not therapists. Cetaceans' role as therapeutic adjuncts (Draper et al., 1990, Mallon, 1992 in Limond et al., 1997) may have to be reevaluated if the psychophysiological mechanisms under investigation are corroborated.

"to the dolphin alone beyond all other, nature has granted what the best philosophers seek: friendship for no advantage"

Plutarch, 62 AD (On the Cleverness of Animals)

Endnote

1 Although beyond the scope of the present review of therapeutic applications of dolphin-human interaction, readers interested in the adjunctive fields of cetacean linguistic and cognitive ability are referred to the seminal studies by L.M. Herman, and the books, audio cassettes and web site of J.C. Lilly, <URL: http://www.garage.co.jp/lilly/>.

Pal, P., (1993). The potential for communication with the intelligent, social dolphins of the ocean. *Oceanography, 115,* is a concise summary and can be found at <URL: http://www.loop.com/~dacs/dolphins.htm>

More extensive reviews can be found at <URL: http://whales.magna.com.au/POLICIES/levasseur/> and <URL: http://earthtrust.org/delphis.html>

References

AquaThought Foundation, Ft. Myers, Florida, USA. (1997). *The AquaThought Foundation briefing.* <URL: http://aquathought.com/ briefing> (Accessed 27/02/1998 10:00).

AquaThought Foundation, Ft. Myers, Florida, USA. (1998). *Captivity FAQ.* <URL: http://aquathought.com/aquamore/captive.html> (Accessed 27/02/1998 10:09).

Birch, S.B. (1995a). *Effects of dolphin-human interaction*. <URL: http://web.access.net.au/%7ediverse/interspecies/reports.htmd/dolhum.html> (Accessed 01/03/1998 12:41).

Birch, S.B. (1995b). *Telemetry monitoring of bottlenose dolphin biosonar during dolphin-human interaction*. <URL: http://www.aquathought.com/idatra/symposium/95/birch.html> (Accessed 27/02/1998 10:21).

Birch, S.B. (1996). *Dolphin therapy effects: A hypothesis*. <URL: http://www.aquauthought.com/idatra/symposium/96/birch.html> (Accessed 27/02/1998 10:23).

Birch. S.B. (1997). *Dolphin-human interaction effects*. Unpublished doctoral dissertation, Monash University, Caulfield Campus, Melbourne, Australia.

Birch, S.B. (1998). *Interspecies research and development*. <Interview with present author> (Melbourne, Australia, May, 1998).

Blackstock, R. (1970). *Dolphins and Man.....equals?* <URL: http://www.polaris.net/~rblacks/dolphins.htm> (Accessed 14/05/1998 7:47).

Blow, R. (1998). *Dr. Dolphin*. <URL: http://www.mojones.com/mother_jones/JF95/blow.html> (Accessed 23/02/1998 9:09).

Bossart, G.D. (1996). *Disease transmission in dolphin-assisted therapy programs: fact or fiction?* <URL: http://www.aquathought.com/idatra/symposium/96/bossart.hltm> (Accessed 27/02/1998 10:22).

Byrd, E. (1995). *The "hello, dolphin" project*. <URL: http://www.aquauthought.com/idatra/symposium/95/byrd.html> (Accessed 11/03/1998 9:16).

Byrd, E. (1998). *The "hello dolphin" project*. <URL: http://www.dolphins.org/learn/dh_thrpy.htm> (Accessed 30/04/1998 21:16).

Cole, D.M. (1995). *Neuro-electrical effects of human-dolphin interaction and sono-chemical hypotheses*. <URL: http://www.aqua

thought.com/idatra/symposium/95/cole.hltm> (Accessed 27/02/1998 10:20).

Cole, D.M. (1996) *Electroencephalographic results of human-dolphin interaction: A sonophoresis model*.<URL: http://www.aquauthought.com/idatra/symposium/96/sonophor/sonophor.html> (Accessed 27/02/1998 10:08).

De Bergerac, O. (1998). *The dolphin within*. Sydney: Simon & Schuster.

Dobbs, H. (1990). *Dance to a dolphin's song.* London: Jonathan Cape.

Dolphin Human Therapy. (Undated). *History*. <URL: http://www.infomall.org/pulsar/dolp_ht/history.html> (Accessed 14/05/1998 10:21).

Dolphin Project International, Ventura, California, USA. (Undated a). *Dolphin swim programs*. <URL: http://dolphinproject.org/swim.htm> (Accessed 09/05/1998 7:42).

Dolphin Project International,Ventura, California, USA. (Undatedb). *Comparison of wild and captive dolphins and whales* <URL: http://dolphinproject.org/ statistics.htm> (Accessed 09/05/1998 7:43).

Erbe, C. (1997). *The masking of beluga whale delpninapterus leucas vocalizations by icebreaker noise*. <URL: http://geop.ubc.ca/~erbe/research.html> (Accessed 08/03/1998 22:33).

Fujii, N., Ukiyo, M., & Aoki, N. (1996). *Dolphin-human communication*. <URL:http://www.t3.rim. or.jp/~icercj/d-hc.html> (Accessed 09/05/1998 8:32).

Giannobile, A. (1996). *The equalized enrichment emphasis*.<URL: http://www.aquauthought.com/idatra/symposium/96/giannobl.html> (Accessed 27/02/1998 10:25).

Hall, R. (1998). Signature sounds. <Interview with present author> (Melbourne, Australia, April, 1998).

Holmes Atwater, F. (1996). *Complementary concepts on the effects of sound on consciousness.* <URL: http://www.aquathought.com.idatra/symposium/96/atwater.html> (Accessed 27/02/1998 10:24).

Hypertek Features. (Undated). *Dolphin Therapy*. <URL: http://www.sfgate.com/hypertek/9706/dolphin_2.shtml> (Accessed 23/02/1998).

Klingel, M. (1996). *The full circle program*. <URL: http://www.aqua thought.com.idatra/symposium/96/klingle.html> (Accessed 11/03/1998 9:21).

LeVasseur, K.W. (Undated). *Three early dolphin experiments funded by the U.S.Nay.* <URL: http://whales.magna.com.au/POLICIES/levasseur> (Accessed 21/05/1998 20:19).

Limond, J.A., Bradshaw, J.W.S., & Cormack, K.F.M. (1997). Behavior of children with learning disabilities interacting with a therapy dog. *Anthrozoös, 10*, 84-89.

Lindeblad, S.K. (1996). *The effect of a unique stimulus*. <URL: http://www.aquathought.com/idatra/symposium/96/lindeblad.html> (Accessed 27/02/1998 10:25).

Lukina, L. (1996). *Results of using Afalina dolphins with a purpose of rehabilitation, social adaption and medical treatment of children in the program called "dolphin therapy"*. <URL: http://www.aquathought.com.idatra/symposium/96/lukina.html> (Accessed 08/03/1998 22:22).

Martens, W.L. (1996). *Human attitudes towards dolphin-assisted therapy: The essential tension between science and faith*. <URL: http://www.aquathought.com/idatra/symposium/96/martens.html> (Accessed 27/02/1998 10:25).

McCulloch, D. (1998). *Synchronicity – the dance of the dolphins*. <URL: http://dolphin-synergy.com/lore.html> (Accessed 09/05/1998 8:10).

Moore, P.W. Web site. *Dolphin echolocation modelling using artificial neural networks*. <URL: http://rap.nas.edu/lab/NRAD/59011001.html (Accessed 14/05/1998 9:00).

Nathanson, D.E. (1980). Dolphins and kids: a communication experiment. *Congress proceedings of the XVI world assembly of the world organisation for preschool education*, 447-451.

Nathanson, D.E. (1989). Using Atlantic bottlenose dolphins to increase cognition of mentally retarded children. In P. Lovibond & P. Wilson (Eds.), *Clinical and abnormal psychology* (pp. 233-242). Amsterdam: Elsevier Science Publishers B.V. (North Holland).

Nathanson, D.E. (1995). *Dolphin human therapy: a professional association dedicated to helping disabled children.* <URL: http://www.aquathought.com.idatra/symposium/95/nathason.html> (Accessed 08/03/1998 22:27).

Nathanson, D.E. (1996). *Dolphin therapy and research*. <URL: http://www.aquathought.com/idatra/symposium/96/nathan.html> (Accessed 27/02/1998 10:24).

Nathanson, D.E. (In press). Long term effectiveness of dolphin therapy for children with severe disability (abstract). *Anthrozoös*.

Nathanson, D.E., de Castro, D., Friend, H., & McMahon,M. (1997). Effectiveness of short-term dolphin assisted therapy for children with severe disabilities. *Anthrozoös, 10*, 90-100.

Nathanson, D.E., & de Faria, S. (1993). Cognitive improvement of children in water with and without dolphins. *Anthrozoös, 6*, 17-29.

Parker, M.J. (1993). Can dolphins heal humans? <URL: http://art1.candor.com/interest/dolphin.htm> (Accessed 21/05/1998 20:40).

Philips, L. (1997). *Dolphin facilitated healing*. <URL: http:// www.premier1.net/~iamdavid/artivle3.html> (Accessed 23/02/1998 9:01).

Pinney, T. (1998). *Human-dolphin interaction.* <URL: http://www.dolphins.org/learn/dh_thrpy.htm> (Accessed 30/04/1998 21:16).

Price, N. (1998). *Dolphins provide therapy in Mexico*. <URL: http://members.aol.com/adrcnet/marmamnews/98032701.html> (Accessed 14/05/1998 10:19).

Reinartz, U. (1998). *Tursiop - Homepage*. <URL: http:www.snafu.de/~ulisses/turiops.htm> (Accessed 19/05/1998 9:05).

Riley, D., & Faulkner, D. (1993). Our love of dolphins has turned into a questionable affair. *Smithsonian, 23*, 58-66.

Schofield, J. (1997a). *Introduction.* <URL: http://www.westwave.com/dtr/introduction.html> (Accessed 09/05/1998 8:44).

Schofield, J. (1997b). *Treatment.* <URL: http://www.westwave.com/dtr/treatment.html> (Accessed 08/03/1998 22:25).

Schwer, S. (1996). *The concept of the therapy in Dolphin Reef.*<URL: http://www.aquathought.com.idatra/symposium/96/schwer.html> (Accessed 08/03/1998 22:28).

Sebastiani, R.A. (1996). *Between the hood and heaven: Utilizing animal-assisted therapy to expand the myopic view of juvenile offenders in inner city facilities and its implications for future dolphin-assisted therapy programs.*<URL: http:// www.aquauthought.com/idatra/symposium/96/sebast.html> (Accessed 27/02/1998 10:24).

Smart, E.M. (1998). *The dolphin and marine medical research foundation.* <URL: http:// dolphins.org/learn/dh_thrpy.htm (Accessed 30/04/1998 21:16).

Suslick, K.S. (1989). The chemical effects of ultrasound. *Scientific American. 260*, 62-68.

The Human Dolphin Institute, Panama City Beach, Florida, USA. (1997). *Child empowerment program*. <URL: http://human-dolphin. org/child_empowerment/program_report.html> (Accessed 09/05/1998 8:41.

The Dolphin Society, Sydney, NSW, Australia. (1998). *Research Program*. <URL: http://eisa.net.au/~dolphins/rprogram.html> (Accessed 09/03/1998 21:34).

The Virtual Dolphin Project, Laguna Niguel, California, USA. (1998). *Our vision for the future*. <URL: http://www.virtualdolphin.org/index.html> (Accessed 14/05/1998 8:36).

Wallace, R.K. (1989). *The neurophysiology of enlightenment*. Fairfield: Maharishi International University Press.

Whale-Watching-Web. (Undated). *Dolphin healing centre opens in Japan.* <URL: http://www.physics.helsinki.fi/whale/japan/kyoto/kyotohea.html> (Accessed 21/05/1998 20:34).

White, B. (1990). "Dolphins are literally dying to amuse us". *Earth Island Journal, 5,* 13.

Acknowledgements

Steven Birch, Interspecies Research and Development
Paul Morgan, Media Manager, Reuters Australia
Dr David Nathanson, Dolphin Human Therapy
Elizabeth Smart, The Dolphin and Marine Medical Research Foundation
Samuel Tof