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Research article

Know when you are on a break: effects of predictable breaks on bottlenose dolphins *Tursiops truncatus* behaviours

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Abstract

Under human care, dolphins' activities are alternated with moments of breaks that should allow them to behave as they want. However, scheduled activities such as training, feeding and playing with objects can affect dolphins' behaviours during breaks. Specifically, dolphins perform anticipatory behaviour to understand what activity is about to start. Here, a method to make breaks effective was tested, that is, to allow animals to behave as they want without being affected by other activities. Specifically, it is proposed that breaks ought to be predictable in order for dolphins to understand when they are taking a break and activities are not scheduled. To evaluate the method, anticipatory behaviour, behavioural diversity and social behaviour of each dolphin *Tursiops truncatus* during predictable breaks was measured and compared to values measured during unpredictable breaks. The findings are consistent with the hypothesis, showing that dolphins reduced their anticipatory activity while significantly boosting their social behaviour and behavioural diversity during predictable breaks compared to unpredictable breaks. Both social behaviours and behavioural diversity, as well as the possibility to freely make choices about how to spend their time, have been positively related to the welfare of many species, including dolphins. Therefore, making breaks predictable seems to be a management strategy that can improve dolphins' welfare.

Introduction

The bottlenose dolphin *Tursiops truncatus* is the most common cetacean hosted at zoos and aquaria (Asper et al. 1990; Clark 2013; Wells and Scott 1999), where it is involved in several scheduled activities such as feeding, training and interaction with humans (Clegg et al. 2017a, 2018; Jensen et al. 2013). These activities have been proven to be positive for many species (Hosey and Melfi 2014; Laule and Desmond 1998; Perelberg and Schuster 2009; Whitham and Wielebnowski 2013) including dolphins (Miller et al. 2011, 2021a; Trone et al. 2005). For instance, the activities can act as enrichment, promoting behavioural diversity and both social and play behaviours (Brando et al. 2019; Miller et al. 2011; Trone et al. 2015). Daily routines organise these activities and alternate them with breaks, that is, moments of free time with no activities scheduled (Clegg et al. 2017a). The breaks are positive moments as animals can perform the behaviours they want. During scheduled activities, dolphins usually perform the behaviours required by caretakers (Serres and Delfour 2017). Conversely, during breaks, dolphins have the opportunity to make their own choices about how to spend their time, which has been positively related to the welfare of many species (Hartley et al. 2019). Scheduled activities can affect dolphin behaviour during breaks (Clegg et al. 2017a). For instance, dolphins can change their behaviour to search for environmental

cues capable of signalling which activity is about to start (Clegg et al. 2017a; Jensen et al. 2013; Serres et al. 2019). This behavioural pattern is called anticipatory behaviour (Spruijt et al. 2001) and is used by animals to try to predict what is going to happen and to prepare for it. Dolphins perform anticipatory behaviour by increasing some behaviours, such as attention behaviours (e.g., spy hopping), and decreasing others, such as social behaviours (e.g., pair swimming) (Clegg et al. 2017a; Jensen et al. 2013; Krebs et al. 2017). Specifically, without signals associated with moments of free time, dolphins do not know when they are on a break and perform anticipatory behaviour to understand which activity is about to start. As a result, during breaks dolphins increase their attention behaviours toward the trainers, on whom most of their activities depend (e.g., feeding, training and playing with objects) and decrease both social behaviours and behavioural diversity (Clegg et al. 2017a; Galhardo et al. 1996; Jensen et al. 2013; Ugaz et al. 2013).

The bottlenose dolphin is a social species in which social behaviours play many functions in social dynamics (Clegg et al. 2017b; Clegg and Delfour 2018; Connor et al. 2006). For instance, social behaviours can promote positive emotional states, social affiliation and provide support to cope with stress (Clegg et al. 2017c; Sakai et al. 2010; Serres et al. 2020a). Such behaviours have been positively related to the welfare of several cetaceans (Clegg et al. 2017b; Clegg and Delfour 2018) and many studies have sought to understand the factors affecting dolphin social behaviours (Clegg et al. 2017a, c; Lauderdale and Miller 2021; Miller et al. 2021a; Serres and Delfour 2017; Serres et al. 2020b; Welsh and Ward 2019). Behavioural diversity is commonly used as an indicator of animal welfare; when it is high it is likely that the environment in which the animals live allows them to satisfy all or much of their needs (Miller et al. 2016, 2020). As a result, zoos and aquaria use management strategies to promote both social behaviours and behavioural diversity, such as providing dolphins with both cognitive and environmental enrichment (Lauderdale and Miller 2020; Miller et al. 2020).

Here, a method was tested to make breaks effective, that is, to allow animals to behave as they want without being affected by other activities. It was hypothesised that for breaks to be effective, they should be predictable so that dolphins know when they are on a break and no activity is planned. Specifically, animals should know what will happen and should no longer need to perform anticipatory behaviour if they are provided with a signal indicating that no activity is about to start. To test the hypothesis, the study was divided into two phases. In the first phase, dolphins were trained to correlate a visual signal with a break. In the second phase, three behavioural parameters, anticipatory behaviour, social behaviours and behavioural diversity were measured and analysed in two different contexts: during morning breaks preceded by the signal (MBS) and during morning breaks not preceded by the signal (MBNS).

If the hypothesis is correct, this study provides a simple method to allow dolphins to behave as they want without being affected by daily activities, as well as increase their social behaviours and behavioural diversity during breaks. From a welfare perspective, a growing number of studies underline the importance of management policies to promote animal welfare (Kuczaj et al. 2002; Lauderdale et al. 2021a–e; Miller et al. 2021a, b; Serres et al. 2020b). Therefore, the findings could be used to create even more comprehensive and effective management policies to promote the welfare of dolphins.

Materials and methods

Facility, animals and study design

The study was conducted from October to December 2018 at Zoomarine dolphinarium, Rome, Italy. Eight bottlenose dolphins *Tursiops truncatus* were divided into two groups and housed in adjacent tanks in compliance with their population's social and breeding requirements. The first group included individuals of different ages and sex, while the second group included only two adult males (Table 1). Throughout the study, the two groups of dolphins were subjected to similar daily routines. In detail, trainers carried out a variable number of training/feeding sessions, ranging from 5 to 12, depending on both training and breeding needs. The first of these sessions was a medical session, used to make a welfare assessment by evaluating bite marks and other injuries. No public presentations were made during the study period as the facility was closed to the public.

First phase

To make breaks predictable, the dolphins were trained to correlate a visual signal, a half-white and half-black panel of 70 × 70 cm, with 10 minutes of break. Training was performed using a procedure described in the literature and based on associative learning (Krebs et al. 2017; Wichman et al. 2012), which in previous studies has been used to teach dolphins to associate a visual signal with the absence of any activity (Bigiani and Pilenga 2021; Clegg et al. 2018). The training was started by showing the signal to the dolphins, who always spontaneously approached and paid attention to it. Then, the signal was left on the tank edge for 10 seconds. During this time, the dolphins were not engaged in any activity (e.g., interaction or play with enrichment, interaction or play with trainers, training, educational sessions, behaviour demonstrations and medical sessions). Finally, the signal was removed and the trainers could now involve dolphins in a new activity. This procedure was repeated for each group once a day for 40 days, increasing the delay between the signal presentation and its removal from 10 seconds to 10 minutes. All dolphins were trained in a group scenario.

Second phase

The three behavioural parameters studied (anticipatory behaviour, social behaviours and behavioural diversity) were analysed during breaks normally performed between scheduled activities. One of the two contexts (morning breaks preceded by the signal, MBS, and morning breaks not preceded by the signal, MBNS) was performed 15 minutes after the trainers finished their activities with the dolphins. For MBS, the signal was first

Table 1. Dolphins' characteristics at the beginning of the study.

ID	Age (years)	Sex	Group name
King	26 (adult)	Male	1
Quina	16 (adult)	Female	1
Leah	16 (adult)	Female	1
Zeus	8 (juvenile)	Male	1
Thai	6 (Juvenile)	Female	1
Luna	1 (juvenile)	Female	1
Marco	20 (adult)	Male	2
Paco	19 (adult)	Male	2

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shown to the dolphins and their behaviours were recorded for 10 minutes, whereas for MBNS, dolphin behaviours were recorded for 10 minutes without showing them the signal. Each day, one observation session was performed for MBNS and one for MBS, randomly choosing the one to start with and leaving at least an hour between observation sessions. In between the two contexts, the trainers performed their daily training and feeding sessions with the dolphins as normal. This procedure was repeated for 10 days, performing a total of 10 observation sessions for MBNS and 10 for MBS.

Each session was recorded with a GoPro Hero 5 Black, which was positioned out of the water to allow recording and monitoring of the entire tank. To calculate the behavioural parameters, video recordings were analysed with BORIS software (Friard and Gamba 2016). To measure anticipatory behaviour, continuous sampling was used (Altmann 1974) during which all dolphins were identified and the percentage of time spent by each on both spy hopping and looking behaviours was recorded (Table 2) (Clegg et al. 2018). Only spy hopping and looking behaviours directed toward the trainers' house, which is in the centre of the dolphinarium and easily visible from each tank, were recorded. As described in Bigiani and Pilenga (2021), between scheduled activities trainers stay in the house and come from there to engage dolphins in a new activity. Therefore, to understand if an activity is about to start, dolphins look towards the trainers' house.

Both social behaviours and behavioural diversity were analysed by sampling every two minutes and thirty seconds (i.e., at 0, 2.5, 5, 7.5 and 10 min of each observation session) (Bernstein 1991). In detail, during sampling, each dolphin was observed for 10 seconds and their behaviour recorded (Table 2). Then, the percentage of social behaviours performed by each dolphin among all behaviours logged was calculated. Shannon's diversity index was used to calculate the behavioural diversity of each dolphin among all observation sessions (Miller et al. 2020).

Statistical analysis

Statistical analysis was performed using OriginPro software (Version 2020, OriginLab, Northampton, MA).

Three Wilcoxon signed-rank tests were run for paired samples to evaluate the effects of predictable breaks on dolphin behaviours. For the first test the dependent variable was the average percentage of time spent in anticipatory behaviour by each dolphin, for the second test, it was the average percentage of social behaviours performed by each dolphin and for the

Table 2. Ethograms used to identify the dolphins' behaviors. The asterisk indicates the behaviors used to measure AB.

Category	Behaviour	Definition
Solitary	Explorative	Investigating or exploring the gates, sides and bottom of the pool or floating non-enrichment objects
	Looking *	Dolphin's head is out of the water and eyes are directed towards a point above the surface
	Pattern swimming	Smooth swimming style at a near constant speed in a repetitive swimming pattern
	Play	Locomotory actions and natural object manipulation
	Resting	Dolphin is on the surface without moving, or moving slowly and with no other identifiable activity
	Spy hopping *	Dolphin propels itself out of the water with the eyes directed to a point above the water's surface
	Stationary	Dolphin remains stationary while positioned vertically in the water column
	Swimming	Dolphin moves independently, not synchronous with any conspecific
Social	Approach	One animal approach another at an oblique angle
	Bite/Rake	Dolphin bites or rakes teeth on another dolphin
	Chase	Rapid and persistent pursuit of another dolphin
	Follow	One animal follows another animal
	Goosing	One dolphin brings its beak into contact with the genital area of another dolphin.
	Hit	Dolphin contacts another dolphin using their rostrum or fluke in a quick manner
	Jaw clap	Dolphin produces a loud popping sound coupled with a fast open and close of the mouth
	Mounting	Dolphin mounts another dolphin by orienting its genital region to another dolphin's genital region
	Pair swimming	Two dolphins swimming together in the same direction and in a synchronous way
	Petting	Two dolphins rubbing their pectoral fins
	Push-up	One dolphin pushes up the genital area of another dolphin, usually with its head or rostrum
	Social sexual petting	One dolphin strokes or inserts its pectoral fin into the genital slit of another
	Social Play	Locomotory actions and natural object play
	Tactile rub	Dolphin contacts or actively rubs any part of their body on the different parts of the pool

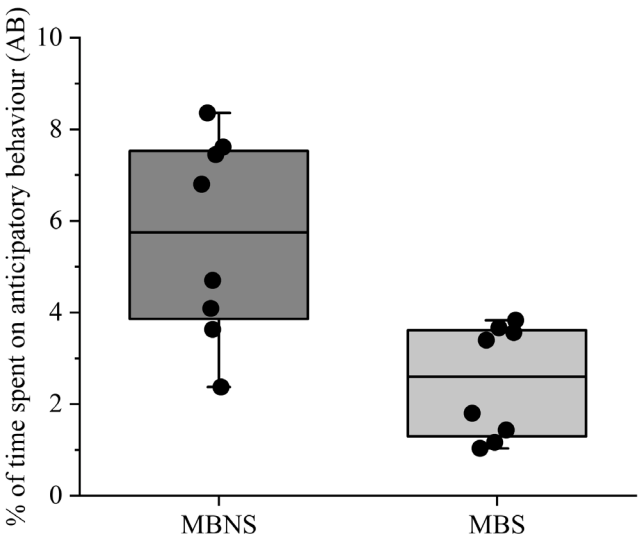

Figure 1. Whisker box plot with the percentage of time spent by dolphins on anticipatory behavior in the two contexts (MBNS and MBS). The horizontal black line inside the box is the median value, the colored box includes data between the twenty-fifth and seventy-fifth percentile, while the error bars are the Min and max values and the black circles the true data. Different colors indicate differences that are statistically significant.

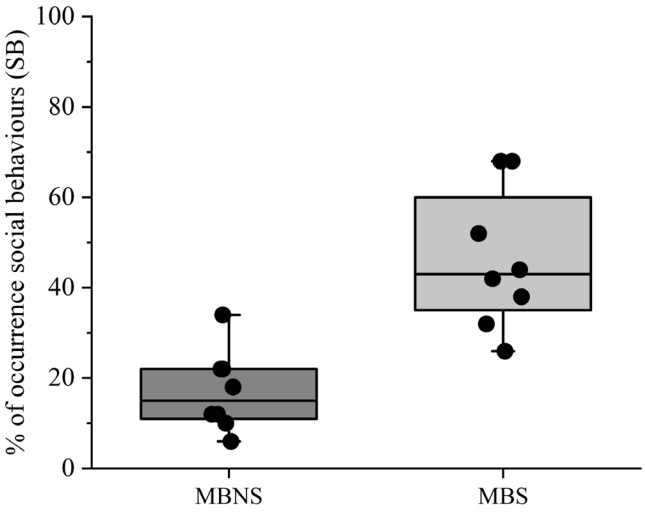

Figure 2. Whisker box plot with the percentage of occurrence of social behaviors in the two contexts (MBNS and MBS). The horizontal black line inside the box is the median value, the colored box includes data between the twenty-fifth and seventy-fifth percentile, while the error bars are the Min and max values and the black circles the true data. Different colors indicate differences that are statistically significant.

third test, it was the Shannon's diversity index of each dolphin's behaviour. With each test dolphin behavioural parameters were compared between the two contexts (MBNS and MBS).

Ethics

This study was developed in compliance with the International Society for Applied Ethology's guidelines for the use of animals in research. It was reviewed and accepted by the scientific and animal welfare committees of Zoomarine. Moreover, the animals' behaviours were monitored to prevent any eventual stress source.

Results

Anticipatory behaviour

Dolphins spent significantly more anticipatory behaviour time during MBNS than MBS ($W=36$, $P<0.01$, Figure 1). Compared to MBNS, anticipatory behaviour decreased by 55% during MBS.

Social behaviours

Dolphins performed significantly more social behaviours during MBS than MBNS ($W=0$, $P<0.01$, Figure 2). Compared to MBNS, social behaviours increased by 172% during MBS. Dolphins primarily increased three social behaviours (pair swimming, social play and follow; Figure 3).

Behavioural diversity

Dolphin behavioural diversity was significantly higher during MBS than MBNS ($W=0$, $P<0.01$, Figure 4). Compared to MBNS, the Shannon's diversity index increased by 59% during MBS.

Discussion

In this study, it was hypothesised that for breaks to be effective, they should be predictable so that the dolphins are informed when no activity is scheduled. Specifically, with a clear signal indicating breaks, dolphins should spend less time on anticipatory behaviour and perform more social behaviours with increasing behavioural diversity. The results support this hypothesis, with anticipatory behaviour decreasing while social behaviours and behavioural diversity increase during MBS compared to MBNS. Under human care, dolphins are often involved in several scheduled activities alternating with breaks (Clegg et al. 2017a, 2018; Jensen et al. 2013). Breaks should allow dolphins to behave as they want, as during scheduled activities they usually perform behaviours reinforced by caretakers (Serres and Delfour 2017). However, many studies show that behaviours displayed during breaks are affected by scheduled activities, with dolphins increasing anticipatory behaviour while decreasing social behaviours and behavioural diversity (Clegg et al. 2017a; Galhardo et al. 1996; Jensen et al. 2013; Ugaz et al. 2013). These findings provide an easy management policy (a signal preceding break time) to make breaks more effective, allowing dolphins to behave as they want during their free time without being affected by other activities.

Management policies have an important effect on determining animal welfare (Meehan et al. 2016; Miller et al. 2021b; Pomerantz and Terkel 2009) and many studies have been conducted to determine the best management policies for dolphins (e.g., Brando et al. 2019; Clegg et al. 2017a, 2018; Delfour and Beyer 2012; Kuczaj et al. 2002; Miller et al. 2011, 2021a; Trone et al. 2005; Ugaz et al. 2013). A longstanding debate surrounds whether

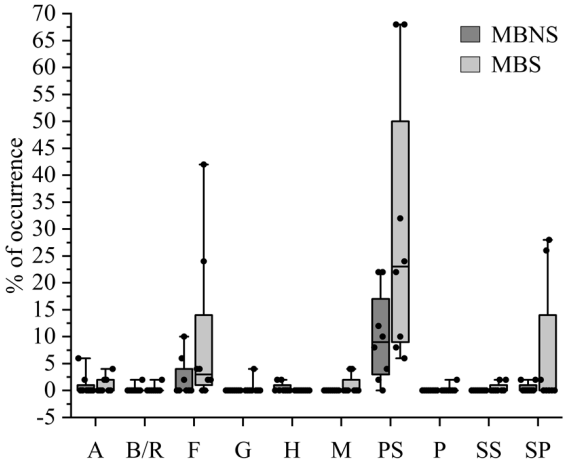

Figure 3. Whisker box plot with the percentage of occurrence of each social behavior recorded at least one time. The letters on the abscissa axis indicate the social behaviors: Approach (A), Bite/Rake (B/R), Follow (F), Goosing (G), Hit (H), Mounting (M), Pair swimming (PS), Petting (P), Social Sexual Petting (SS), and Social Play (SP). The horizontal black line inside the box is the median value, the colored box includes data between the fifteenth and seventy-fifth percentile, while the error bars are the Min and max values and the black circles the true data.

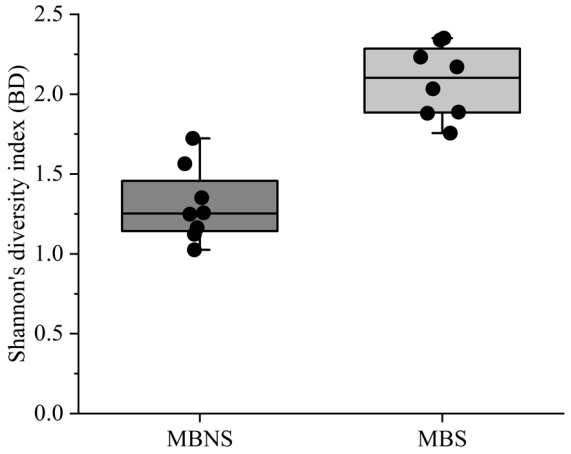

Figure 4. Whisker box plot with the Shannon's diversity index in the two contexts (MBNS and MBS). The horizontal black line inside the box is the median value, the colored box includes data between the fifteenth and seventy-fifth percentile, while the error bars are the Min and max values and the black circles the true data. Different colors indicate differences that are statistically significant.

activities in which animals are involved should be predictable or not (reviewed in Bassett and Buchanan-Smith 2007). Recent research indicates that predictable or semi-predictable activities, rather than unpredictable ones, improved welfare for bottlenose dolphins (Lauderdale et al. 2021a, d; Miller et al. 2021a, b). This study supports these findings and suggests that MBS is positive for dolphin welfare. First of all, during MBS dolphins have the opportunity to make their own choices about how to spend their time without being affected by scheduled activity, which has been related to the welfare of many species including marmoset *Callithrix jacchus* (Buchanan-Smith and Badihi 2012), Western lowland gorilla *Gorilla gorilla gorilla* and chimpanzee Pan troglodytes (Kurtycz et al. 2014) and African *Loxodonta africana* and Asian *Elephas maximus* elephants (Hartley et al. 2019). Secondly, during MBS dolphins increased social behaviours, which has been related to dolphin welfare (Lauderdale and Miller 2021). For instance, social play is inversely related to agonistic behaviours and is performed only when an individual's primary needs are fulfilled (Bateson 2014; Held and Špinka 2011; Serres et al. 2020b). Furthermore, pair swimming is a key behaviour in dolphins. It can promote reconciliation after a conflict (Holobinko and Waring 2010) and the formation of alliances (Connor et al. 2006; Connor 2007); it can provide social support to cope with stress (Serres et al. 2020a), strengthen social bonds (Clegg et al. 2017c; Sakai et al. 2010) and promote positive emotional states (Clegg et al. 2017c; Serres et al. 2020a). Generally, SB plays many roles in dolphin social dynamics, promoting group cohesion and maintaining both social bonds and social dominance between individuals (Clegg et al. 2017b; Clegg and Delfour 2018; Connor et al. 2006; Serres and Delfour 2019). As a result, some authors include social behaviours among positive indicators of dolphin welfare (Clegg et al. 2017b; Clegg and Delfour 2018). Third, during MBS dolphins increased behavioural diversity, which is used as a positive indicator of welfare in many species (Miller et al. 2020) and has recently been applied in bottlenose dolphins (Delfour et al. 2021). Behavioural diversity is considered a good indicator of animal welfare because animals with high behavioural diversity probably live in an environment able to satisfy all or much of their needs (Miller et al. 2016, 2020). However, some studies underline that behavioural diversity must be interpreted and used with caution, as there is a lack of studies that, for example, correlate behavioural diversity with physiological stress parameters (Miller et al. 2020). As a result, although the increase in behavioural diversity is probably positive, more studies will be needed to completely understand its relationship with dolphin welfare.

In summary, this study indicates that MBS acted as an enrichment programme for dolphins. Indeed, during MBS dolphins had the opportunity to choose which behaviour to perform and they increased species-appropriate behaviours, which are goals of enrichment programmes (Alligood and Leighty 2015; Lauderdale et al. 2021d).

Unfortunately, this study involved only eight dolphins all housed in the same facility, which may limit interpretation of the results as well as their possible future application to promote welfare. Future studies should complement the current observations with various measures of both physiological and behavioural welfare. In this scenario, a good starting point might be to evaluate the dolphins' willingness to participate in training sessions performed after MBS and MBNS. Indeed, the willingness of dolphins to participate has recently been validated as an indicator of dolphin

welfare (Delfour et al. 2020). Other work should integrate these observations with moments of pause in which dolphins can use environmental enrichment, which in a recent study proved to increase dolphin activity by up to 50% (Lauderdale et al. 2022). Although future studies with larger sample sizes and in other facilities will be needed to confirm the current findings, making breaks predictable appears to be a management policy that may improve dolphin housing conditions.

Conclusion

Under human care, dolphins' activities are alternated with moments of break that should allow them to behave as they want. In this study, a signal was provided to the dolphins to make their break predictable and whether predictable breaks are more effective than unpredictable ones was evaluated. The results confirm this hypothesis, with dolphins spending less time in anticipatory behaviour and increasing both social behaviours and behavioural diversity during predictable breaks compared to unpredictable breaks. Therefore, this method could be useful for animal management in a controlled environment, reducing the effect of scheduled activities on animal behaviour.

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