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## Acoustic behaviour of bottlenose dolphins under human care while performing synchronous aerial jumps

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► **To cite this version:**

Juliana Lopez Marulanda, Olivier Adam, Chloé Huetz, Fabienne Delfour, Sander Vanderheul, et al.. Acoustic behaviour of bottlenose dolphins under human care while performing synchronous aerial jumps. *Behavioural Processes*, 2021, 185, pp.104357. 10.1016/j.beproc.2021.104357 . hal-03181087

**HAL Id: hal-03181087**

<https://hal.sorbonne-universite.fr/hal-03181087v1>

Submitted on 25 Mar 2021

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1 **ACOUSTIC BEHAVIOUR OF BOTTLENOSE DOLPHINS UNDER HUMAN CARE**  
2 **WHILE PERFORMING SYNCHRONOUS AERIAL JUMPS**

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52 **SUMMARY STATEMENT**

53 Bottlenose dolphins under human care emit click trains when synchronising requested  
54 aerial jumps. During these jumps, only one individual produces the click trains while  
55 its partner eavesdrops on this acoustic leader.

56

57 **ABSTRACT**

58 Synchronous behaviours occur when two or more animals display the same behaviour  
59 at the same time. However, the mechanisms underlying this synchrony are not well  
60 understood. In this study, we carried out an experiment to determine whether or not  
61 Bottlenose dolphins use acoustic cues when performing a known synchronised  
62 exercise. For this, we recorded three dolphins while they performed requested aerial  
63 jumps both individually or synchronously in pairs, with a hydrophone array and a 360°  
64 underwater video camera allowing the identification of the subject emitting  
65 vocalisations. Results indicated that in pairs, dolphins synchronised their jumps 100%  
66 of the time. Whether they jumped alone or in pairs, they produced click trains before  
67 and after 92% of jumps. No whistles or burst-pulsed sounds were emitted by the  
68 animals during the exercise. The acoustic localisation process allowed the successful  
69 identification of the vocalising subject in 19.8% of all cases (N=141). Our study showed  
70 that in all (n= 28) but one successful localisations, the click trains were produced by  
71 the same individual. It is worth noting that this individual was the oldest female of the  
72 group. This paper provides evidence suggesting that during synchronous behaviours,  
73 dolphins use acoustic cues, and more particularly click trains, to coordinate their  
74 movements; possibly by eavesdropping on the clicks or echoes produced by one  
75 individual leading the navigation.

76

77 *Key Words: dolphin, echolocation, eavesdropping, localisation, hydrophone array,*  
78 *synchronicity*

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## 85 INTRODUCTION

86

87 Synchrony is defined as the precise coincidence of events in time (Ravignani, 2017).  
88 Thus, synchronous behaviours occur when two or more animals perform the same  
89 behaviour at the same time (Connor et al., 2006), and have been described for several  
90 animal species in different sensory modalities (e.g., visual, acoustic) (reviewed in  
91 Herzing, 2015). The degree of synchronisation varies from time intervals of less than  
92 one second, to several minutes (Sakai et al., 2010). For example, visual synchrony  
93 occurs between fireflies (*Pteroptyx spp.*) that synchronise their bioluminescent  
94 flashing at night (Buck, 1988), and between male fiddler crabs (*Uca annulipes*) that  
95 wave their major claws in synchrony in order to attract females (Blackwell et al., 1999).  
96 Examples of acoustic synchrony have been described in the courtship vocalisations  
97 of male long-tailed manakins (*Chiroxiphia linearis*) (Trainer and McDonald, 1993) and  
98 male frogs (*Kassina kuvangensis*) (Grafe, 2003). Many synchronous animal displays,  
99 such as those mentioned above, are driven by competition (Ravignani et al., 2014).  
100 Some species, however, perform synchronous behaviours linked to cooperation. This  
101 is the case for humans during sports and musical activities (Launay et al. 2016), as it  
102 is for dolphins (*Tursiops truncatus*) when allied males synchronise their vocal  
103 behaviour to coerce females (Moore et al., 2020).

104

105 In dolphins, the term “synchrony” has been used in two different ways. First, to  
106 describe group members that perform non-random grouping behaviours, such as  
107 swimming and breathing in synchrony (Hastie et al., 2003; Fellner et al., 2013); and  
108 second, to describe behaviours that are performed ‘simultaneously’ or ‘in unison’  
109 (Mann and Smuts, 1999; Connor et al., 2006). Simultaneous behaviour has been  
110 described in several dolphin species. Pantropical spotted dolphins (*Stenella attenuata*)  
111 synchronise their movements as a defensive response while being herded in tuna nets  
112 (Pryor and Kang-Shallenberger, 1991). Synchronous behaviour has been reported in  
113 Atlantic spotted dolphins (*Stenella frontalis*) as a means of dominating larger sized  
114 opponents (i.e., Bottlenose dolphins (*Tursiops truncatus*)) during aggressive  
115 interspecific interactions (Cusick and Herzing, 2014). Male Indo-Pacific Bottlenose  
116 dolphins (*Tursiops aduncus*) have been observed to synchronise their surfacing  
117 behaviour during social interactions with female consorts (Connor et al., 2006; Sakai

118 et al., 2010) and whilst herding females (Connor et al, 1992; Connor and Smolker,  
119 1996), but also as a signal of alliance unity and a means to maintain and strengthen  
120 social bonds (McCue et al., 2020).

121 Vocal synchrony has also been described in a number of species: Spinner dolphins  
122 (*Stenella longirostris*) synchronise their vocalisations when dispersing from bays  
123 (Brownlee and Norris, 1994) and during cooperative prey herding (Benoit-Bird and Au,  
124 2009). Offshore populations of Bottlenose dolphins (*Tursiops truncatus*) have shown  
125 evidence of vocal synchrony in order to maintain contact in a large home range (Janik  
126 et al., 2011). Finally, simultaneous vocal and visual signals have been reported for this  
127 same species during intraspecific aggressions (Herzing, 2015).

128  
129 Sounds emitted by dolphins are classified into three structural categories and two  
130 functional classes. Structurally, sound production is thus categorised into whistles or  
131 tonal sounds (reviewed in Janik, 2009), clicks or pulsed sounds (Au et al., 1974), and  
132 burst-pulsed sounds (Diaz-Lopez and Bernal-Shirai, 2009). Functionally, whistles and  
133 burst-pulsed sounds play a role in communication and social interactions (reviewed in  
134 Herzing, 2000). Clicks, however, are used for echolocation, which can be defined as  
135 the acoustic representation of one's surroundings, obtained by the production and  
136 emission of clicks and the subsequent nervous integration of the perceived echoes  
137 (Au, 1993).

138  
139 Vocalisations associated with cooperative behaviours have been described in  
140 Bottlenose dolphins (Eskelinen et al., 2016) and killer whales (Van Opzeeland et al.,  
141 2005). Such cooperative behaviours do not necessarily involve the expression of the  
142 same movement or behaviour in a fully synchronised manner. However, the fact that  
143 there is a communicative process during cooperation in these experiments, leads us  
144 to believe that when two or more dolphins engage in a synchronous behaviour,  
145 information may be flowing between them. This flow of information can involve a  
146 communication process (Johnson, 2015) and may occur by use of one of several  
147 sensory channels. Underwater, visibility can be limited (i.e., turbidity, depth, light), in  
148 contrast, sound travels well (Tyack and Clark, 2000). Therefore, the expression of  
149 acoustic cues to synchronise behaviours is a plausible assumption.

150

151 The use of acoustic cues to perform simultaneous movements is difficult to investigate  
152 in free-ranging dolphins for two main reasons: First, low visibility underwater in most  
153 of their habitats (Würsig and Pearson, 2015) (with the exception of a few locations  
154 such as the Bahamas (Herzing, 1996) or Fernando de Noronha in Brazil (Silva Jr. et  
155 al., 2005)) allow neither clear determination of the degree of synchronicity, nor the  
156 localisation of the individual emitting the sound. Second, even with good visibility, the  
157 occurrence of synchronous behaviours, the identification of the individuals performing  
158 them and the replication of tests cannot be controlled by the experimenter.

159

160 Management of dolphins under professional care provides a favourable opportunity to  
161 study the mechanisms underlying synchronisation due to the fact that a synchronous  
162 behaviour can be requested from the target animals and be replicated several times.  
163 The clarity of the water and the proximity for observations allows for direct recording  
164 of behavioural sequences as well as the identification of the individual emitting a  
165 vocalisation by use of a hydrophone array.

166 Dolphins in human care facilities regularly engage in behaviours simultaneously (e.g.,  
167 jumps) and, through positive reinforcement, can be trained to display these  
168 synchronous behaviours upon request (Brando, 2010). However, it is unknown how  
169 dolphins manage to synchronise their actions and whether or not they use acoustic  
170 cues to coordinate their simultaneous behaviours. The first aim of this study was to  
171 explore the potential involvement of acoustic cues during a simultaneous exercise  
172 requested by a caregiver (or trainer). Thus, if synchronisation relies on the emission  
173 of acoustic signals, one might assume that acoustic signals will be emitted during the  
174 exercise and that acoustic cues will be different depending on whether the individuals  
175 perform the exercise alone or in synchronisation with another individual. The second  
176 aim of the study was to identify the category of sounds emitted during such an  
177 exercise, as well as the identity of the emitters.

178

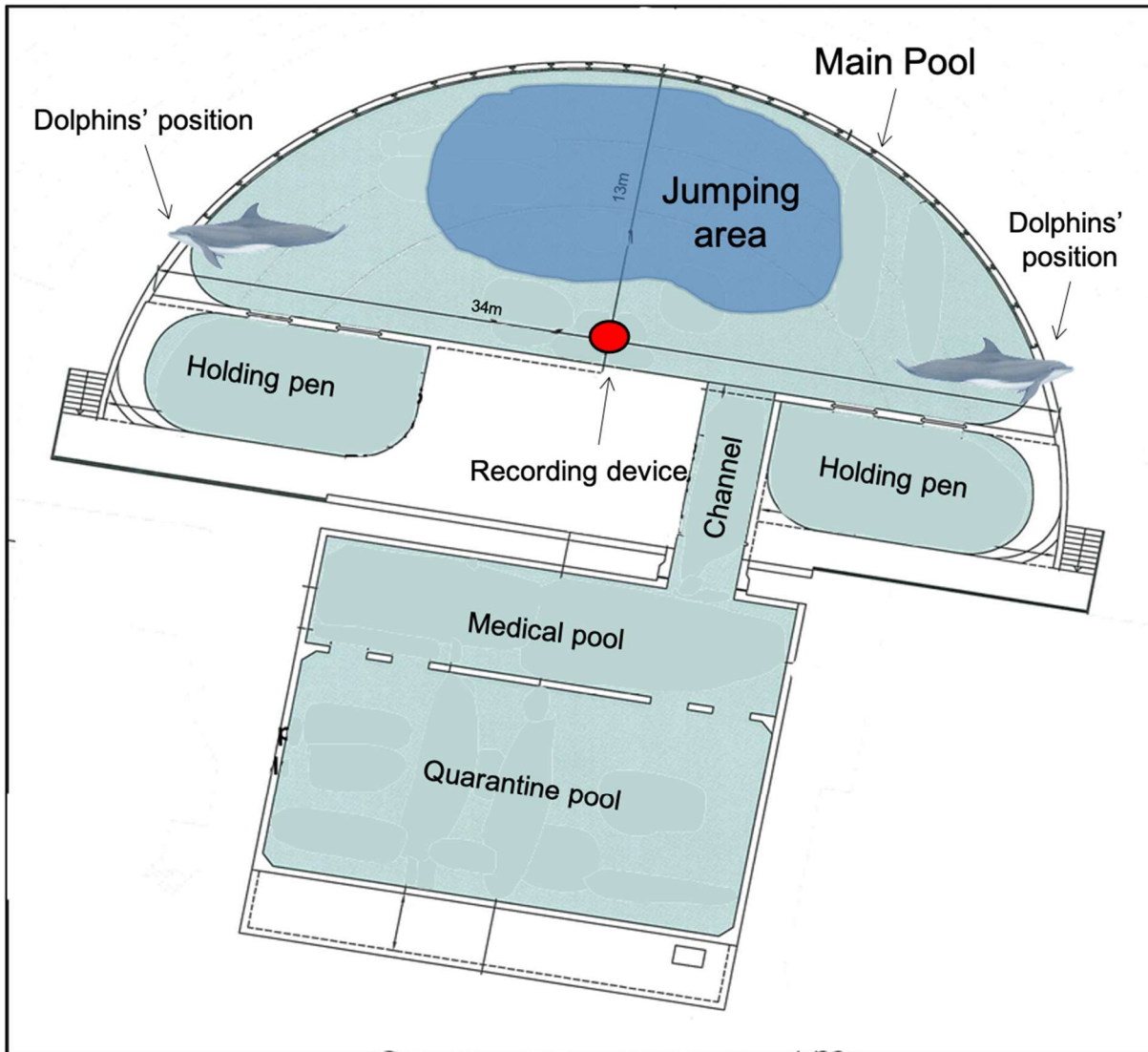
## 179 **METHODS**

180

### 181 *Study subjects and facility*

182 The synchronisation experiment was conducted in February and March of 2017, at the  
183 Boudewijn Seapark (Bruges, Belgium). Overall, this facility consists of five connected

184 pools that are not acoustically isolated: a main presentation pool, two holding pens, a  
185 medical pool and a quarantine pool. The depth of the pools is 3 m in the shallowest  
186 areas and 5.6 m at the deepest point of the main show pool (Figure 1). The training  
187 sessions with caregivers take place in all pools, but the experiment was carried out in  
188 the main pool.



189  
190 Figure 1: Top view of the enclosure at the Boudewijn Seapark (Belgium). The  
191 location of the hydrophone array during the recordings is marked by a red dot.  
192 During the experiment, the tested animals were placed at opposite sides of the main  
193 pool. At each trial the dolphins moved to the centre of the main pool (jumping area)  
194 to perform the jumps.

195  
196 Of the **X** Bottlenose dolphins (*Tursiops truncatus*) present on site, three were selected  
197 for the experiment: two adult females, Puck and Linda, aged 51 and 41 years

198 respectively (F51 and F41), and one sub-adult male, Kite, aged 12 years (M12). They  
199 have been living together in the facility since May 14<sup>th</sup>, 2014. Puck has always been  
200 the dominant female of the group. According to the caregivers, she displays a low  
201 compatibility to work with Kite (M12) but a high compatibility to work with Linda (F41)  
202 (i.e., they can perform exercises together without any conflict arising). The two females  
203 originate from the wild, while the male was born in another facility. The choice of these  
204 dolphins was based on two criteria: Firstly, the three animals had undergone several  
205 years of training to perform the same exercise both individually and collectively.  
206 Secondly, their training for performing this exercise began at the same period,  
207 meaning that no individual was more experienced than the others.

208

209 During the experiment, the other group members were kept in the two holding pens,  
210 and a trainer was responsible for maintaining their heads above water to avoid the  
211 propagation of their potential acoustic emissions through the pools. This procedure  
212 prevented erroneous localisation of the emitting individual, as vocalisations originating  
213 from outside the experimental pool could be detected and localised during acoustic  
214 processing.

215

216

### 217 *Recording device*

218 Simultaneous audio and video recordings were collected using a 360° audio-video  
219 system, BaBeL (BioAcoustique, Bien-Être et Langage) (López Marulanda *et al.*, 2017).  
220 Underwater video data was collected using a GIROPTIC 360° video camera with three  
221 lenses covering 120° each, allowing a 360° view of the main pool. Audio recordings  
222 were conducted with four synchronised hydrophones at a sampling frequency of  
223 96 kHz and coded in 24 bits. Details regarding the functioning of this hydrophone array  
224 are described in Lopez-Marulanda *et al.* (2017). The distance between the  
225 hydrophones varied from 2.4m to 3m. This system has been tested in a pool with  
226 artificial sounds and presents an accuracy of  $\pm 10^\circ$  in localising the direction of the  
227 sound's source (Lopez-Marulanda *et al.*, 2017). In addition, we used a GoPro hero 3+  
228 to record a back-up video of the experiment as seen from the surface. Videos and  
229 audio recordings were synchronised. A single video file was created from the 360°  
230 video camera and was associated to the audio track obtained by BaBeL and its



231 corresponding spectrogram (FFT size: 1024, overlap 50%, Hanning window) which  
232 was obtained using the software Audacity 2.0.6 (GNU General Public License).

233

234 Before the beginning of each experimental session, the BaBeL device was set up in  
235 the main pool, suspended from a buoy and held in place using two ropes fixed to the  
236 sides of the tank and a pole held by a motionless observer at the pool's edge (Figure  
237 1).

238

### 239 *Habituation process*

240 Before carrying out the experiment, the dolphins were gradually habituated to the  
241 presence of the BaBeL device in the water. The habituation process involved six one-  
242 week phases, which were gradually built-up over the period leading up to the recording  
243 sessions. The first phase consisted in positioning the device on the side of the main  
244 pool, out of the water, but within sight of the subjects. In the second phase, a caregiver  
245 held the device while standing on a raised, mobile, underwater platform located in the  
246 channel that connects the main pool to the quarantine pool. During this phase, the  
247 subjects could see the device in the water but their attention was controlled by other  
248 trainers (i.e., when necessary, they were distracted in order to avoid any contact with,  
249 and potential damage to the equipment). During the third phase, the subjects were  
250 allowed to swim freely for a limited time in presence of the device which was held by  
251 a trainer as described in phase 2. Exploration time was gradually prolonged, and  
252 subjects were rewarded for ignoring the device. In the fourth phase, the device was  
253 suspended in the water while the subjects' attention was controlled by the trainers. In  
254 the fifth phase, the device was left alone in the pool while the subjects swam around  
255 freely. They were provided with enrichment items in order to distract them from the  
256 BaBeL equipment. In the final phase, the device was randomly placed in the water,  
257 with or without the presence of enrichment items.

258

### 259 *Experiments*

260 The "backflip" (i.e., jumping with the dorsal part of the dolphin facing the water's  
261 surface) was selected for use in the experiment, as this exercise, both individually and  
262 collectively, had been known to the study subjects for several years. In both cases,  
263 whether individually or collectively, the dolphins perform the backflip repetitively until  
264 the trainer blows a whistle to indicate that the task had been well performed and that

265 they can be rewarded (fish). For the experimental sessions, and depending on the  
266 subjects' motivation, the trainers decided to let them jump between one and five times  
267 before blowing the whistle (i.e., to indicate the end of the requested exercise).

268

269 We carried out 30 experimental sessions (max. two per day) in which subjects were  
270 asked to perform the “backflip” exercise. During each experimental session, trainers  
271 asked subjects to perform the “backflip” exercise five non-consecutive times. Each  
272 “backflip” exercise requested by a gestural command was considered a trial. Each trial  
273 varied in duration, beginning when the trainer asked the subject to perform the  
274 “backflip” and ending when the trainer blew the whistle indicating that the behaviour  
275 could be stopped and that a reward was available. Between trials, other exercises  
276 were carried-out in order to maintain the dolphins' motivation. The facility's schedule  
277 allowed us to carry out a total of 150 trials during the experiment. We aimed to get at  
278 least 30 repetitions of the exercise performed solo in order to carry out robust statistical  
279 analyses. Given that there were three subjects, we needed at least 90 trials in order  
280 to obtain these repetitions for each subject. We then decided to use the remaining 60  
281 trials for two different pair combinations: 30 trials for Kite (M12) and Puck (F51) that  
282 had low compatibility for working together, and 30 trials for Linda (F41) and Puck (F51)  
283 that had high compatibility for working together. As a pair, Linda and Kite were not  
284 tested.

285

286 In order to facilitate the localisation process and to test the spontaneity of the  
287 synchronous behaviour for the trials performed collectively, the dolphins were  
288 positioned at opposite sides of the main pool (Figure 1), each facing a trainer standing  
289 at the pool's edge. As such, each subject could see only the trainer's gestural  
290 commands directed at them and not those directed at the other subject. Once in  
291 position, the trainers produced the command to perform the backflip. These backflips  
292 were performed by the dolphins in the “jumping area”, located in the centre of the main  
293 pool (Figure 1).

294

295

### 296 *Behavioural analysis*

297 Underwater BaBeL videos and backup surface videos were analysed frame-by-frame  
298 in order to determine whether or not subjects jumped synchronously. A synchronous

299 jump is achieved when the rostrums of both individuals break through the water's  
300 surface within 1/30 of a second of one another.

301

302

### 303 *Localisation processing*

304 Firstly, a visual inspection of the click trains allowed us to determine whether they were  
305 produced by the just one subject (i.e., a regular click train, with an increasing,  
306 decreasing or constant inter-click interval (ICI)) or by more than one subject (i.e.,  
307 irregular click train with no pattern of change in the ICI, a consequence of a  
308 presumable overlap of more than one click train). The localisation process was  
309 possible only when there was an absence of overlapping click trains.

310

311 Secondly, for the 60 trials carried out in pairs, localisation processing of the click trains  
312 was performed using a customised program created in MATLAB®, Version 2013a  
313 (Mathworks, Natick, MA, USA) (Blanchard, 2015) in order to identify which dolphin(s)  
314 emitted the vocalisations. This program uses a geometrical localisation method to  
315 estimate the positions of the acoustic sources. More specifically this method relies on  
316 the spatial distribution of the hydrophones and the measurement of the Time Delays  
317 Of Arrival (TDOA) of the acoustic wave from the sources, to the different hydrophones  
318 in order to calculate the positions of the sound source. The localisation was then  
319 displayed in the 360° video (see supplementary material) by a conversion position-  
320 pixel (Lopez-Marulanda *et al.*, 2017).

321

### 322 *Acoustic analysis*

323 The acoustic analysis was based on click train production alone, as no whistles or  
324 burst-pulsed sounds were emitted by the subjects during the “backflip” exercise.

325 Click trains were defined as a series of four or more similar clicks with successively  
326 shorter ICIs (Roberts and Read, 2015). They were analysed using the pulse train  
327 analysis function of Avisoft-SASLab Pro version 5.2.07 (Raymond Specht, Berlin,  
328 Germany) in order to measure the click rate (number of individual clicks per second)  
329 for each trial. Click trains produced after the last jump of each trial (immediately after  
330 the trainer blew the whistle) were not taken into account for the pulse train analysis.  
331 This is due to the fact that click trains emitted after the trainer's whistle, for all subjects,  
332 had similar features to a “victory squeal” or a “reward spectating buzz”, a high-click-

333 rate vocalisation that has been described previously by several authors (Ridgway et  
334 al., 2014; Dibble et al., 2016). If taken into account, this higher click rate could have  
335 been a source of bias for the statistical analyses.

336

### 337 *Statistical analyses*

338 Comparisons between the three individuals' click rates were performed using a  
339 Kruskal-Wallis test and post-hoc comparisons with Mann-Whitney tests. To assess  
340 whether the click rates differed between the exercises performed in solo or in pairs,  
341 we used a Wilcoxon signed rank test for each individual. All statistical tests were  
342 conducted using R statistical software version 3.02 (R Core Team, 2013).

343

## 344 **RESULTS**

345

### 346 *Synchronous behaviour*

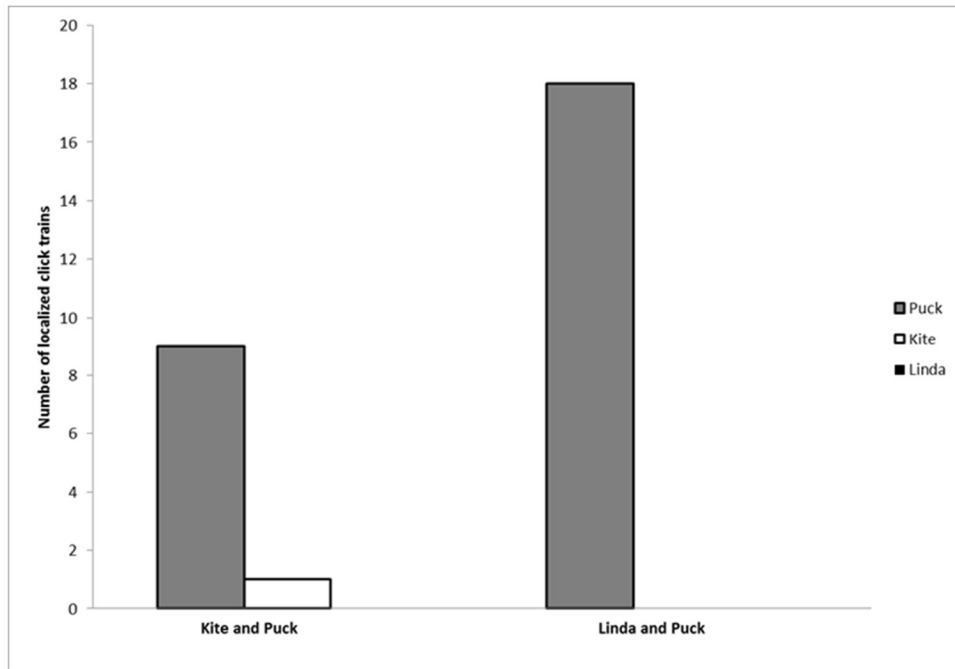
347 Video analyses showed that 100% of the “backflips” performed in pairs were  
348 synchronous. Inspection of the synchronised spectrogram indicated that for 92% of  
349 the jumps performed, dolphins produced a click train just before and after each backflip  
350 (Table 1). In addition, the time elapsed between the signal given by the trainer and the  
351 backflip varied between 2.40 and 5.12 seconds (mean 3.8 seconds).

352

### 353 *Localisation process*

354 Visual inspection of audio recordings showed that 98% of the click trains emitted  
355 during collective jumps (N=141) did not overlap. These vocalisations can therefore be  
356 considered to be produced by one individual only.

357 Localisation processing was carried out for the 141 click trains produced during  
358 collective exercises in order to assess the emitters' identity. In 103 cases (73.1%), the  
359 localisation was not achieved due to the reverberation of the sounds against the walls  
360 of the pool. In 10 cases (7.1%) the localisation was ambiguous because the two  
361 dolphins were placed one behind the other with respect to the camera. Finally,  
362 successful localisation was achieved for 28 (19.8%) click trains, 18 for the Linda/Puck  
363 (F41/F51) pair and 10 times for the Kite/Puck (M12/F51) pair. Puck (F51) was  
364 identified as the individual producing the clicks for all 18 trials (100% of the  
365 successfully localised trials) with Linda (F41) and for nine of the 10 trials (90%) with  
366 Kite (M12) (Figure 2).



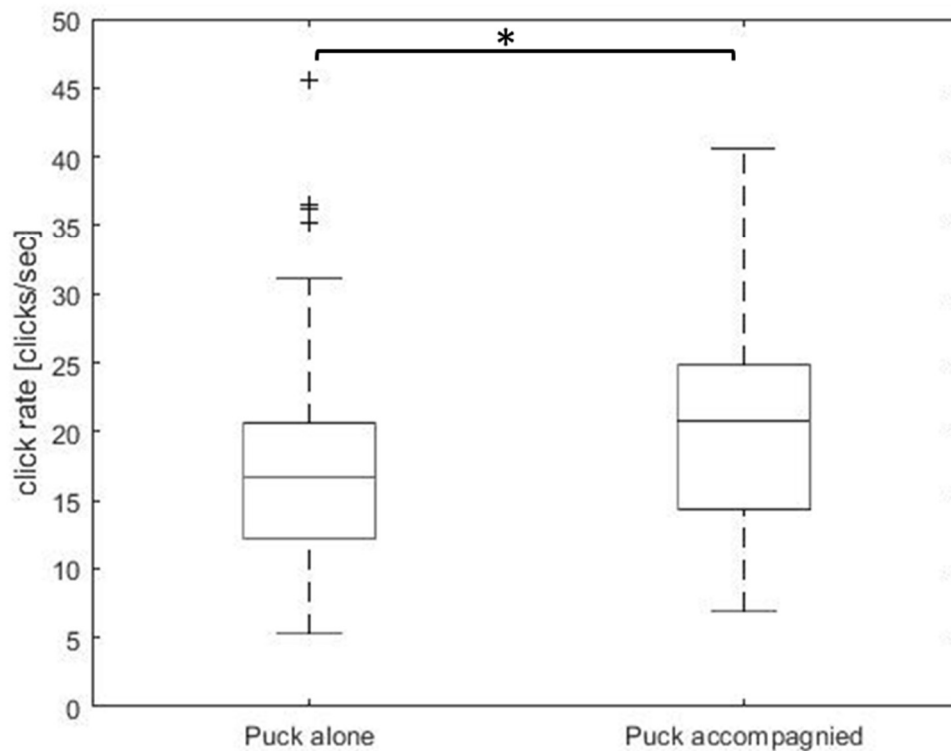
368

369 Figure 2: Number of successfully localised click trains for each pair (n=28): Puck  
370 (F51), Kite (M12) and Linda (F41).

371

372 *Comparison between click rates of localised click trains*

373 As specified above, localisation processing allowed for the identification of Puck,  
374 almost exclusively, as the click train emitter. Comparisons between pair and solo  
375 conditions revealed that click rates produced by Puck were significantly higher when  
376 jumping with a partner (median: 20.77 clicks.sec<sup>-1</sup>) than when jumping alone (median:  
377 17.6 clicks. sec<sup>-1</sup>) (Wilcoxon signed Rank Test: W=626, P=0.043) (Figure 3).



378

379

380 Figure 3: Comparison between click rates of click trains produced by Puck (F51)  
 381 when performing backflips alone and accompanied. Boxes represent 25<sup>th</sup> and 75<sup>th</sup>  
 382 percentiles. Whiskers correspond to the 1<sup>st</sup> and 99<sup>th</sup> centiles. + represents the  
 383 outliers. \* indicates P values < 0.05

384

385 To summarise, our results show that the dolphins always performed the exercise in  
 386 synchrony, even if the gestural commands were given to each individual separately.  
 387 We also demonstrate that subjects produced click trains when jumping both in solo  
 388 and in pairs. Click trains produced when jumping in pairs were, for the large majority,  
 389 produced by one individual only. Localisation processing was successful in 19.8% of  
 390 all cases (N=141). When successfully localised, results showed that, in 90%  
 391 (Kite/Puck pair) and 100% (Linda/Puck pair) of cases, the individual producing the  
 392 click trains was the older female, Puck (Figure 2). Detailed analyses, based exclusively

393 on Puck's click production, confirmed a significant increase of her click rate when  
394 performing the exercise in pairs.

395

## 396 **DISCUSSION**

397 In this experiment we studied the behaviour of three individuals, and two different pair  
398 combinations. Our results show that when dolphins are asked to perform synchronised  
399 jumps in pairs, only one of the two individuals involved emits vocalisations.

400 The low success rate for the localisation process can be explained by the fact that the  
401 dolphins carry out the exercise where they want in the pool. As a result, they are not  
402 necessarily placed in an optimal manner to allow for successful localisation. This  
403 limitation can be mitigated if we assume that every click train emitted in the pool had  
404 the same probability of being correctly localised. Indeed, localisation data collected  
405 during solo jumps (therefore, no ambiguity regarding the emitter) support this  
406 assumption, since the localisation was achieved for 20.1% of cases, a value close to  
407 the 19.8% achieved for the collective jumps.

408

409 Dolphin pairs were requested to synchronise their backflip even if the signal was given  
410 by two different trainers positioned on two opposite sides of the pool. The time elapsed  
411 between the signal from the trainers and the backflip varied between 2.4 and 5.12  
412 seconds. This supports the fact that this behaviour is not a stereotypical jump that  
413 would be carried-out automatically and invariably, after a precise delay following the  
414 gestural command. It seems there is a temporal adjustment between the dolphins that  
415 allows the observed synchrony. Synchronisation has been observed in the wild, where  
416 free-ranging dolphins spontaneously synchronise their movements and postures  
417 (Pryor and Kang-Shallenberger, 1991; Cusick and Herzing, 2014; Connor et al., 2006;  
418 Sakai et al., 2010; Connor et al., 1992; Connor and Smolker, 1996). An obvious

419 question requires the identification of the cues used by these animals to synchronise  
420 their behaviour. The aim of this study was to test whether the acoustic modality plays  
421 a role in the performance of a synchronous action. Although we do not exclude the  
422 possibility that visual cues were used to produce simultaneous movements in the clear  
423 waters of this facility, our results suggest that acoustic cues might also be relevant to  
424 a certain extent. It is in fact reasonable to think, according to the parsimony principle,  
425 that if click trains, which have an energetic cost of production, are systematically  
426 emitted at each trial, they might play a role in the performance of the requested  
427 exercise. In addition, we demonstrated that the modality of click emission during solo  
428 trials (i.e., click trains produced by each dolphin jumping) differed from those observed  
429 during the collective synchronised trials (i.e., click trains produced by one dolphin only  
430 while the other remained quiet). Together, our results suggest that the acoustic  
431 channel might be used during the performance of synchronous jumps.

432 No whistles or burst pulsed sounds were produced during the jump exercise, whether  
433 performed alone or in pairs. These sounds have been reported to play a role in  
434 communication and social interactions (Herzing, 2000) and studies on Bottlenose  
435 dolphins under human care (Eskelinen et al., 2016) and on wild killer whales (Van  
436 Opzeeland et al., 2005) have shown that clicks are not the primary vocalisation emitted  
437 during a cooperative task. In our study we did not investigate cooperation in problem  
438 solving (i.e., hunting for fish or obtaining fish from a container), but synchrony in  
439 movement, a task that might require acoustic cues that serve mainly to navigate, as  
440 clicks do. Furthermore, during the exercise, subjects performed an assigned and  
441 known behaviour when they were the only two individuals in the pool, meaning that  
442 they knew both what to do and who to do it with. Under these conditions, dolphins are



443 probably not required to produce “communication vocalisations” to interact socially or  
444 to recruit a particular partner among a group of conspecifics.

445 Our results reveal that while performing a synchronous behaviour, a single individual  
446 emitted the click trains. There are two possible explanations for this behaviour: First,  
447 the dolphin that produces the click trains during the synchronised jumps, is using its  
448 sonar to echolocate its partner’s movements. This, however, seems unlikely, as it does  
449 not explain why dolphins that produced clicks during solo jumps remained silent during  
450 collective jumps. The second possible explanation for this behaviour is that one of the  
451 dolphins remains quiet in order to eavesdrop on the clicks produced by its partner and  
452 that it uses this acoustic information (likely in combination with visual cues) to navigate  
453 and perform the jump as efficiently as it does when jumping alone. Dolphins can  
454 perform object recognition through echoic eavesdropping (Xitco and Roitblat, 1996,  
455 Götz et al., 2006; Gregg et al., 2007), we suggest here that echoic eavesdropping  
456 might also be used for navigation. The key question that may be raised is whether this  
457 potential role allocation is done randomly or depends on the dolphin’s identity and  
458 status in the group.

459

460 We showed that in all (n=28) but one successful localisations, the click trains were  
461 produced by the same individual, suggesting that one dolphin might acoustically lead  
462 the other during the exercise in pairs. It is worth noting that this individual was the  
463 oldest of the group (Puck). However, this subject did not have more training or perform  
464 the exercise better than the other two. Puck is likely to be the leading female of the  
465 group, as it has been described that in Bottlenose dolphins, under human care, the  
466 oldest females are often group leaders (Samuels and Gifford, 1997). In our study,  
467 Puck’s leadership may be expressed through her predominant acoustic activity when

468 paired with another individual. Also, when accompanied, Puck showed an increased  
469 click rate when performing the exercise, which might serve to facilitate coordinated  
470 movements. Our results suggest that Puck led the acoustic activity during the  
471 performance of synchronised jumps. Leadership has been defined as a situation  
472 where an individual steers the behaviour of others (King et al., 2009), and it has been  
473 reported in highly dynamic fission-fusion species, such as free-ranging Bottlenose  
474 dolphins, when they travel (Lewis et al., 2010). Our experiment supports this  
475 hypothesis and gives a possible explanation for a mechanism used to synchronise  
476 movements. This pilot study, therefore, lays the first foundations of these crucial and  
477 exciting questions. However, further investigation is needed to reveal which factors  
478 influence this leadership.

479 We cannot exclude the possibility that dolphins have learned to produce click trains  
480 while performing the “backflip” exercise by auto-shaping. This is defined as a form of  
481 conditioning in which a subject that has been given reinforcement following a stimulus,  
482 regardless of its response to that stimulus, consistently performs an irrelevant  
483 behaviour (Brown and Jenkins, 1968). If so, the dolphins would systematically produce  
484 click trains while performing the “backflip” exercise, which is not the case. Auto-  
485 shaping may also have led the dolphins to learn to remain quiet while another dolphin  
486 produces click trains. However, this alternative still implies that the behaviour (silence)  
487 appeared spontaneously, at least at the beginning of the learning process.

488 In conclusion, this study provides evidence that dolphins emit acoustic cues, and more  
489 particularly click trains, when performing known synchronised movements.  
490 Furthermore, when carrying out these synchronised movements, one individual  
491 possibly eavesdrops on the echoes produced by its partner and this probably helps  
492 them to navigate their own jump.

493

494 **Acknowledgments**

495 We would like to thank the trainers at the Boudewijn Sea Park (Bruges, Belgium) and  
496 Nikolaas Colpaert for his invaluable collaboration with the development of this  
497 experiment. Thanks to Isabelle Charrier and the members of the Bioacoustics team  
498 (NeuroPSI) for their advice and support during the data analyses.

499

500 **COMPETING INTERESTS**

501 All authors declare that they have no competing interests.

502

503 **FUNDING**

504 This research received no specific grant from any funding agency in the public,  
505 commercial or non-profit sectors.

506

507

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