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Analysis of sperm whale (*Physeter macrocephalus*) dialogues, click by click: an ethoacoustic approach

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Introduction & Objective

Sperm whales (Pm) communicate using clicks. Understanding their social exchanges requires assigning each click to its emitter. However, overlapping emissions among similarly sized individuals near the surface make this attributions challenging. How can each click be reliably assigned despite overlapping click trains ?



Study context & Materials

- **Program:** "La Voix Des Cachalots" (Longitude 181) ^[2,3,4].
- Opportunistic passive underwater observations off Mauritius.
- Tool: OPALE antenna: 3 hydrophones + 2 GoPros, high-definition datasets, developed by SMIOT & DYNI ^[5].
- **Subjects:** Dyadic interactions between juvenile males born the same year, with repeated exchanges.
- Social behavior observed:



OPALE antenna 2023

array coupled with audio-video recordings, to analyse an undocumented socio-acoustic interaction between two juvenile males of the same age.

Method 1: Source localisation

Objective: Assign each click to the individual

Fig.2: Array of three hydrophones used to calculate click arrival times



'Vocal sparring' between juvenile male sperm whales.

Method 2: Acoustic identification

Objective: Separate overlapping click trains emissions



Fig.4: Processing pipeline for dimensionality reduction and HDBSCAN clustering

Preliminary Results

Track 1			Track 2	
0.2 -				

Example analysis:

Cluster 0	I constant	
0.4 - Cluster 1	ICI	IC





Fig.6: Source locations of 7 clicks overlaid, from track 1, on a GoPro video frame. Each dot represents a click; colours indicate the six-year-old juvenile males who produced them: Ali (red) and Daren (green). 14 sec audio-video sequence containing 2 overlapping click trains (tracks 1 & 2, fig.5), totalling 84 clicks.

- Method 1: precise attribution of clicks to a visually identified individuals.
- Method 2: reliable separation of overlapping clicks.

Manual post-processing: clicks not assigned to a cluster were attributed based on ICI continuity.
Combination of both methods: successful individual assignment, even in complex overlapping situations.



Fig.7: Clustering of 37 clicks from track 2 using UMAP for dimensionality reduction and HDBSCAN, following global z-score normalisation.



Fig.8: Clustering results visualised on the waveform, with each click assigned to an individual: Ali (red), Daren (green). Blue clicks, initially unclustered, were reassigned to the green cluster based on ICI values ^[1].



Fig.9: CQT patches of nine clicks (9 ms window). Ali: red frame; Daren: green frame, based on clustering results from fig.7,8.

Discussion & Conclusion

The two methods developed in this study are complementary :

The protocol allows reliable individual attribution, supporting detailed exploration

- Method 1 offers high spatial accuracy but is limited by distance from the array and acoustic reflections near the surface.
- Method 2 effectively separates overlapping click trains from two individuals but is more sensitive to noise, out-of-water emission, and less stable over long sequences.

Audio/video cross-analysis validates clustering results and resolves ambiguities. **ICI tracking** improves the attribution of isolated or unclustered clicks. This study provides the first documentation of a vocal interaction between two juvenile males of the same age, with a strong social affinity. of social and vocal dynamics in juvenile male Pm. Preliminary findings suggest that click trains **can be acoustically distinct**, even among individuals of the similar age.

This raises research questions:

- Do stable individual acoustic signatures exist?
- Are observed differences solely attributable to click orientation?

Ethological perspectives: opens up promising opportunities for studying:

- intra-clan social structure,
- individual specificity in click production,
- the potential communicative functions of certain click patterns.

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