SCANDLE

acoustic **SC**ene **AN**alysis for **D**etecting **L**iving **E**ntities

Aim: to develop a system that is able to identify and distinguish living beings from inanimate objects, on the basis of sound alone: *a cognitive acoustic scene analysis system.* This system will be able to detect living beings exclusively through the use of information derived from sounds, combining:

- **Passive detection:** of sounds generated or caused by living beings through their movements or utterances to extract information such as their emotional state, gender or state of health.
- **Active probing:** using a micro-sonar device, which emits sounds that bounce off objects. Using the frequency changes in the sounds that bounce off living beings caused by their movements, the system will learn to recognise patterns of frequency changes that characterise intentional behaviour.

Micro-Doppler spectrogram of a person walking towards the sonar. L and R mark regions representing the motion of the left and right legs, respectively. T points to a region around 40.35 kHz, corresponding to the motion of the torso, walking speed ~1.5 m/s. Features below 40 kHz are Doppler shifts caused by movements away from the sonar.

Real-time digital/analogue hardware system

Implement a passive/active acoustic sensing system to detect and localise living beings and classify their movements in real-time, using an event-based distributed architecture; a *wireless cortex*.

Perceptual Organisation in Natural Systems

Experiments to understand:

- how information relating to different sound sources is organised *on the fly* to form stable representations of auditory objects;
- what conditions lead to the formation of new objects;
- how the system deals with ambiguity;
- neural processes involved in perceptual organisation.

Computational Modelling

Develop neuro-computational models of:

- autonomous perceptual organisation.;
- bio-sonar processing, pattern recognition and behaviour classification;
- integrated passive and active sound processing.

Neuromorphic Engineering takes inspiration from biology, physics, mathematics, computer science and engineering to design artificial neural systems for carrying out robust and efficient computation using low-power, massively parallel analogue VLSI circuits, that operate with the same principles used in the brain.

The role of stimulus features in the formation and maintenance of auditory objects

Winkler I, Denham SL, Nelken I. (2009). Modeling the auditory scene: predictive regularity representations and perceptual objects. Trends Cogn Sci. 2009 Dec;13(12):532-40. A review defining auditory objects and their relationship to auditory streams; showing that they are derived from multi-scale regularities in the acoustic signal.

Bendixen, A., Jones, S.J., Klump, G., Winkler, I. (accepted). Probability dependence and functional separation of object-related and mismatch negativity event-related potential components. NeuroImage.

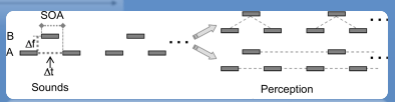
- Indicators of object formation are different from those signaling mismatched predictions
- Strength of object formation signal is sensitive to global probability
- Detection of a new object, but not its absence, leads to involuntary attentional capture

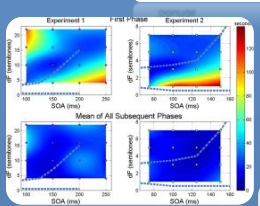
Denham, S.L., Gyimesi,, K., Stefanics, G., Winkler, I. (submitted). Perceptual bi-stability in auditory streaming: How much do stimulus features matter? Biological Psychology.

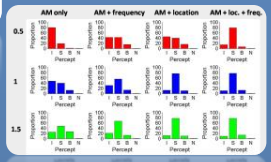
- Perceptual switching is found for all stimulus parameters tested (Δf, Δt, ΔAM, Δlocation), even in stable regions of the parameter space.
- Two phases of perceptual organization: first has longer duration and is sensitive to primary features, subsequently switching is more rapid, and relatively insensitive to primary features.

Bendixen, A., Denham, S.L., Gyimesi,, K., Winkler, I. (submitted). Regular patterns stabilize auditory streams. J Acoust Soc Am.

- Regular patterns help to stabilize auditory streams , but do **not** trigger their formation.







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