# Enhancing sound through touch

Sarah Poyntz  Supervisors: Adrian Rees, Quoc Vuong

Newcastle University
Institute of Neuroscience

## Introduction

There is evidence showing that our senses may interact through certain brain mechanisms. Examples of interaction of senses and intermodal interaction:

- **Auditory visual**

Previous studies that have been done in my supervisors' lab have demonstrated how hearing can be influenced by what we see.

- **Auditory tactile**

There is some evidence showing that when both tactile and auditory stimuli have the same frequency, sound can influence tactile judgements (Yau et al 2009).

## Research questions

1. **Does a tactile stimulus influence the depth of a modulated sound?** This hypothesis is explored in experiment 1a.
2. **Does a modulated sound influence the depth of a modulated tactile stimulus?** This hypothesis is explored in experiment 1b.
3. **Does tactile stimulation improve identification of words in speech** This hypothesis is explored in experiment 2.

## Method Experiment - 1a & 1b

**Stimulus**

Figures showing examples of amplitude modulated sounds: **duration 1.5s**

'DIFFERENT' 'SAME'

Tone amplitude-modulated at 2Hz, depth **52%** (fig. 1A)

Tone amplitude-modulated at 2Hz, depth **20%** (fig. 1B)

Tone amplitude-modulated at 2Hz, depth **52%** (fig.1C)

Tone amplitude-modulated at 2Hz, depth **52%** (fig. 1D)

- Experiment 1a: trials - pairs of sounds with same or different modulation depth. Subject's task: is the pair 'same' or 'different'?
- Modulation depths used 20%, 28%, 36%, 44% or 52%.
- 'Different' trials: one interval 20%, other interval: 28, 36, 44, or 52%
- 'Same' trials: same modulation depth in both intervals.
- In Experiment 1b, same as Experiment 1a, but with pairs of modulated tactile stimuli.

**Apparatus**

- Auditory stimuli played through headphones. Tactile stimulus generated by a tactile stimulator that delivered a vibration to the finger tip (fig.4).
- Subject responses recorded using computer keyboard.

**Procedure**

- Example experiment 1a, discrimination of modulated sounds measured with and without a tactile stimulus modulated at 70% depth.

Figure 2A Figure 2B

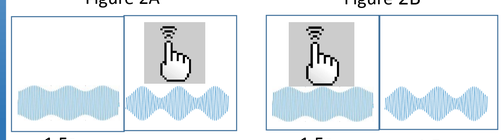



Figure 2A, > shows tactile stimulation present on more modulated sound.
Figure 2B, < shows tactile stimulation present on the less modulated sound.

- Tactile stimulation was either congruent (cong) or incongruent (incong) with the sound. **'<'** *i.e. less than* refers to the second stimulus being present on the less modulated primary stimulus. **'>'** *i.e. more than* refers to it being present on the more modulated one. Incong, cong and with < and > are the different conditions.
- Example experiment 1b, discrimination of two tactile stimuli measured in presence or absence of a sound modulated at 70% depth.

Figure 2C Figure 2D

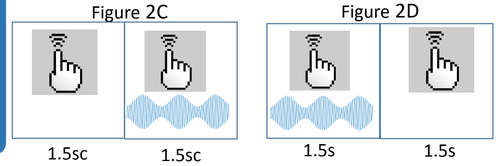
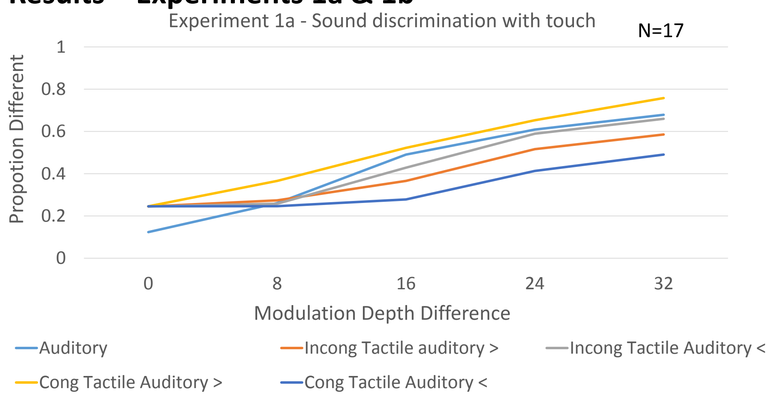
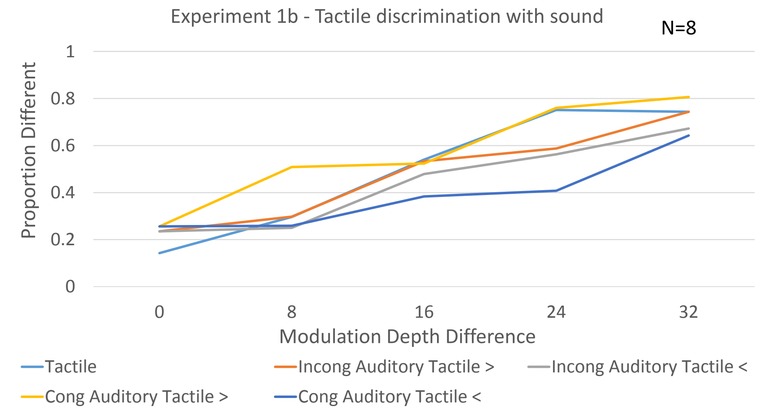



Figure 2C, > shows more modulated sound present during tactile stimulation .
Figure 2D. < shows more modulated sound present during tactile stimulation.

## Results – Experiments 1a & 1b




## Method - Experiment 2

Participants were invited from a pool of healthy volunteers. Ages from 19 - mid 60's.

**Stimulus**

- Sentences were taken from a standard set, referred to as 'IEEE sentences'. These contain many grammatically correct but unpredictable sentences and no sentences were repeated throughout the experiment.
- The tactile stimulus is created by extracting the amplitude envelope from the sentence in order to modulate the amplitude of the tactile vibration.

**Apparatus**

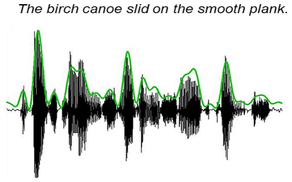
- A vibrator provides a tactile stimulus created from the speech envelope of different sentences. The computer is used to record number of key words repeated successfully.

**Procedure**

- The ability to recognise speech in the presence of background noise was compared to ability of speech recognition in the presence of the tactile stimulus.
- The participant listened to sentence and was asked to repeat it.
- The sentence was played in the presence of background noise with or without tactile stimulation.
- The effect of the tactile stimulus synchronous to the auditory stimulus is then measured.

*The birch canoe slid on the smooth plank.*

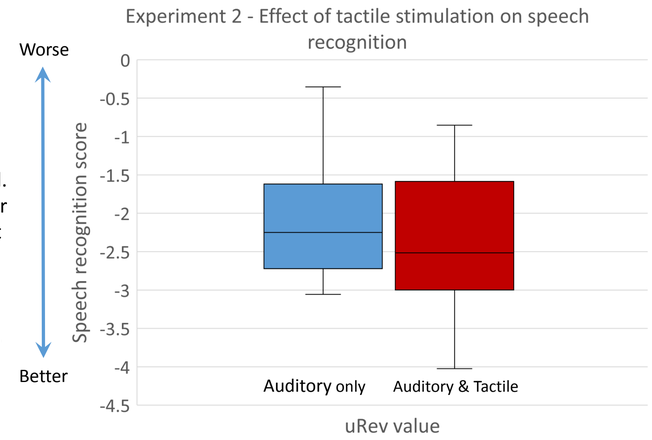
Speech envelope corresponding to tactile stimuli (figure 3)



Tactile vibrator (figure 4)

## Results – Experiment 2

A '0' speech recognition score means both the background noise and the auditory stimulus are equal. A negative number means the subject can hear majority of the sentence during louder background noise.




## Discussion

Experiment 1a & b

- A positive correlation between modulation depth difference and the ability to discriminate the difference in the two sounds.
- Therefore the greater the modulation difference, a higher proportion voted 'different'.

In experiment 1a, when the two stimuli were congruent (cong);

- If the tactile stimulus was present during the more greatly modulated sound, a greater proportion of subjects voted 'different' compared to incong values.
- When the tactile stimulus was present during the less modulated sound, a higher proportion of subjects voted 'same'.

In experiment 1b, when the two stimuli were congruent (cong);

- If the auditory stimulus was present during the more greatly modulated vibration, a greater proportion said 'different' compared to incongruent (incong) values.
- When the auditory stimulus was present during the less modulated vibration, a higher proportion voted 'same'.

Experiment 2

- In the auditory only task, the speech recognition score was less negative compared to the auditory tactile task. The mean uRev for the auditory tactile task was **-2.196 dB** compared to **-2.058 dB** for the auditory only task.
- The median speech recognition score was also more negative for the auditory tactile task therefore majority of the participants scored better in the auditory tactile task.

## Conclusion

Experiment 1a

- The presence of tactile stimulation had a influence on discrimination of the two sounds when stimuli were synchronous.

Experiment 1b

- The presence of auditory stimulation had a influence on discrimination of two vibrations when stimuli were synchronous.

Experiment 2

- Results showed the ability to recognise words in background noise improved in the presence of the tactile stimulus.
- A more negative value for the auditory tactile task shows the subject can hear the sentences under a higher level of background noise with tactile stimulation.

## Acknowledgment

Supported by vacation scholarship from the Wellcome Trust