Laughter and Light: A Near-Infrared Window into Social Behaviour

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Background

Technological advances are making it possible to address the philosophical challenge of defining human behaviour. Previous tools for analysing social interactions have either been subjective, physically confined, or have limited ecological validity. The purpose of this study is to demonstrate how functional near-infrared spectroscopy (fNIRS) can be used to cross-culturally examine social behaviour.

The accurate perception of non-verbal vocalisations is fundamental for behaviours seen across the animal kingdom.[1] A prime example of these sounds is laughter, which is universally recognised and allows for a rare cross-culture investigation of social interactions.[2] Our current work seeks to investigate the relationship between a participant's neural process underlying the detection and processing of volitional laughter, which is produced socially, and spontaneous laughter, which is internally generated and uncontrolled.

Behavioural Testing

Previous work demonstrated that people can detect the differences in socially produced and spontaneously emitted laughter.[3] To test this, all 10 participants completed a behavioural test, where they listened to 19 different laughter sounds, which were each about 2 seconds long.[4] Subjects were asked to rank the level of authenticity and contagion for each sound on a scale of 1 to 7, with 1 being the lowest and 7 the highest.

Results showed significant differences in how the volitional and spontaneous laughter was perceived for contagion ($p<0.0003$) and authenticity ($p<0.001$).

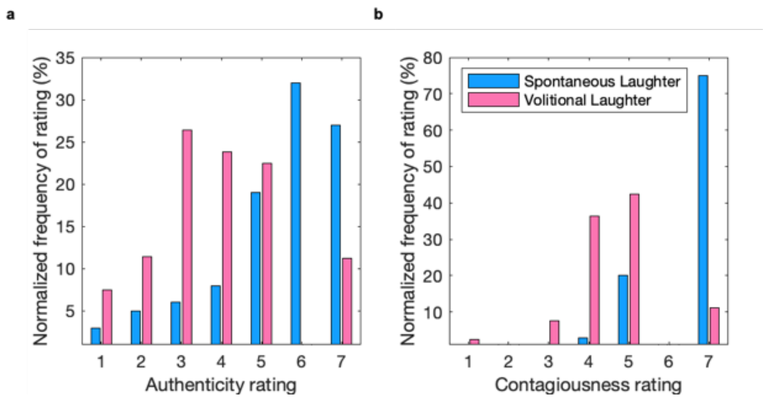


Figure 1 Comparison of subject's rating of levels of contagion and authenticity for volitional and spontaneous laughter sounds.

fNIRS Testing

Changes in haemoglobin concentration in response to laughter sounds were recorded using a Hitachi ETG-4000 multi-channel fNIRS system. A total of 52 fNIRS channels were obtained from an array spanning portions of the frontal, parietal and temporal lobes. Subject-specific anatomical and optode positioning data was collected using a Polhemus Patriot digitizer. A stimulus paradigm consisting of previously described laughter recordings were played in 16 second blocks with jittered timing while the participants were instructed to stare at a blank computer screen and focus on the sounds.

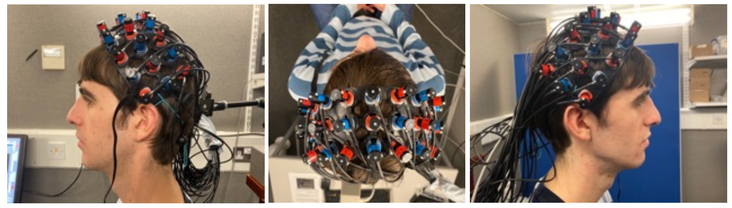


Figure 2 fNIRS data collection. A subject with cap on to demonstrate placement.

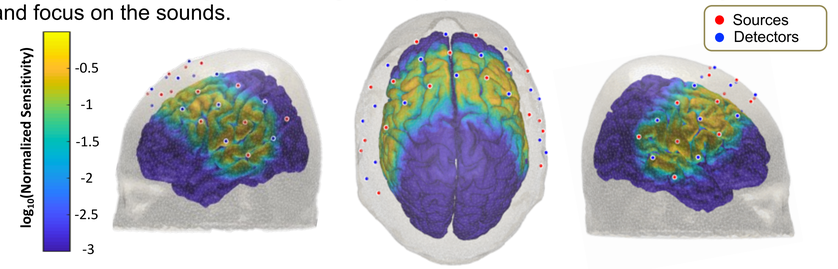
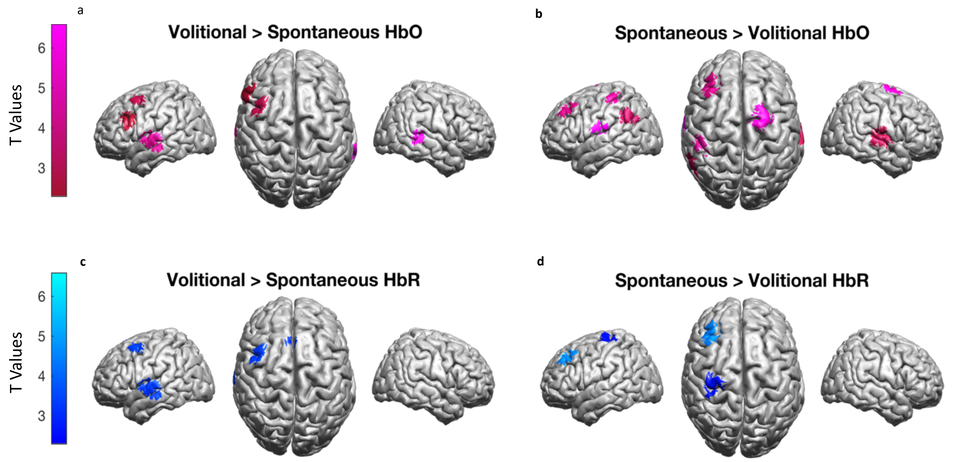


Figure 3 The grid array was placed on the scalp at a location designed to maximise the sensitivity to the temporal lobes and motor areas. The sensitivity of the probe was calculated with the forward model in Atlasviewer[7].

Using the AnalyzIR toolbox, the autoregressive pre-whitening iteratively reweighted least squares AR(P)-IRLS general linear model was used to statistically account for physiological noise such as respiration, heart rate, and blood pressure.[5] A baseline principal component analysis (bPCA) filter was then applied to reduce spatial covariance.



Chromophore	Volitional > Spontaneous	t
HbO	L superior temporal gyrus	4.07**
	R superior temporal gyrus	5.84***
	L middle frontal gyrus	2.86*; 2.36*
HbR	L superior temporal gyrus	3.20**
	L middle frontal gyrus	3.29**
	L medial superior frontal gyrus	2.97**
Chromophore	**Spontaneous > Volitional**	**t**
HbO	L superior frontal gyrus	3.90**
	L somatosensory cortex	6.59***
	R superior temporal gyrus	2.82*
	L inferior parietal lobe	3.04*
	L primary motor cortex	4.09**
	R supplementary motor area	5.18***
HbR	L superior frontal gyrus	4.45**; 2.55*
	L somatosensory cortex	2.25*

Figure 4 The results of the t-tests on β values produced by the GLM. Significant responses were projected onto the Colin-27 atlas demonstrating regions of significance. Where responses were greater listening to volitional than that for spontaneous are shown in the first column (a,c). Regions where the spontaneous was greater than that for volitional laughter are shown in the second (b,d). Those t values and level of significance is shown in (e), where * $q<0.05$ ** $q < 0.01$ ***$q<0.005$

Conclusions

These responses are consistent with the fMRI and EEG literature using laughter stimuli, demonstrating the reliability of fNIRS measurements for this experimental paradigm. Future directions for this work will be focused on the neural correlates of the processing and production of laughter in infants. While this study employed fNIRS, we intend to undertake fuller studies of human laughter using Diffuse Optical Tomography (DOT).

DOT is silent and the wearable HD-DOT technologies that are now emerging can be applied in almost any environment, including while subjects naturally interact with one another.[8] As a result, DOT is uniquely suited to the study of social interaction and with an increased variety of clinical populations. More ecologically valid tools will enable a deeper understanding of human social behaviour.

1 Kreifelts, Benjamin, et al. *Neuroimage* 37.4 (2007): 1445-1456. 2 Sauter, Disa A., et al *Proceedings of the National Academy of Sciences* 107.6 (2010): 2408-2412. 3 Lavan, Nadine, et al. *Neuropsychologia* 95 (2017): 30-39.4 Szameitat, D. P. *et al. J. Acoust. Soc. Am.* **126**, 354–366 (2009). 5 Santosa, Hendrik, et al. *Algorithms* 11.5 (2018): 73. 6 Hotelling, H. 54–65 (Springer New York, 1992).7 Aasted, C. M. *et al. Neurophotonics* **2**, 020801 (2015). 8 Dai, Bohan, et al. *Nature communications* 9.1 (2018): 2405.