

THE NORMAL AND ABNORMAL PROCESSING OF PITCH PATTERN

Jessica Melanie Foxton

PhD Thesis

July 2004

University of Newcastle upon Tyne

School of Neurology, Neurobiology and Psychiatry

CONTENTS

Abstract	v
Publications Arising from Thesis	vi
Acknowledgements	vii
1 General Introduction	1
2 General Methods	29
3 Pitch Pattern Perception and Reading Skills	41
4 Pitch Perception in ‘Tone Deafness’	63
5 Training to Improve Pitch Pattern Analysis	94
6 Pitch Pattern Analysis in Autism	117
7 General Discussion	137
8 Appendices	162
9 References	165

LIST OF FIGURES

1-1. The voice fundamental frequency over time	2
1-2. Illustration of ‘local’ and ‘global’ information in pitch sequences	7
1-3. Illustration of stimuli in Dowling and Fujitani study (1971)	10
1-4. Results from the study of Patterson <i>et al.</i> (2002)	19
2-1. Local pitch sequence change	33
2-2. Global pitch sequence change	34
3-1. Illustration of the second and third formants in /ba/ and /da/	45
3-2. Scatter plot of the ‘global’ pitch contour score and Raven’s matrices	51
3-3. Scatter plots of the pitch sequence scores and non-word reading time	52
3-4. Scatter plots of the pitch sequence scores and orthographic recognition	53
3-5. Scatter plots of the pitch sequence scores and NART scores	54
3-6. Scatter plots of the pitch sequence scores and non-word repetition	55
4-1. Pitch threshold tasks	72
4-2. Pitch sequence tasks	75
4-3. Illustration of the temporal coherence boundary	77
4-4. Illustration of the fission boundary	78
4-5. An example of a Weibull fit for the scores from one of the subjects	79
4-6. Thresholds on the pitch tasks	81
4-7. Scores on the pitch sequence tasks	83
4-8. Temporal coherence boundary over runs	85
4-9. Fission boundary over runs	86

5-1. ‘Global’ pitch-contour sequence discrimination task	99
5-2. Visual-auditory contour discrimination task	100
5-3. ‘Local’ actual-pitch sequence discrimination task	101
5-4. Pre- and post-training scores on the sequence tests	108
5-5. Scores on the training tasks	110
6-1. Examples of the pitch direction tests	127
6-2. Example of the comparison test	128
6-3. Performance on the pitch-direction tests	130
7-1. Additional level in Dowling’s model	143
7-2. The ‘Navon’ figure	149

ABSTRACT

The studies presented in this thesis investigate the importance of pitch-pattern processing for normals and those with developmental disorders. This was achieved by assessing the perception of ‘global’ contour patterns of rises and falls in pitch and ‘local’ actual pitches. The first experimental study investigated individual differences in pitch-pattern processing. It was found that pitch contour perception relates to reading skills, which suggests that this aspect of audition may be important for the acquisition of literacy. The second study investigated pitch-pattern perception in ‘tone-deaf’ individuals. Deficits were found for both pitch contour and actual-pitch perception, which suggests that these auditory features are important for normal music processing. A further study demonstrated that it is possible to improve pitch contour perception with training. This suggests that it may be possible to improve the perception of natural sounds through such training. The final study investigated whether there are abnormalities in pitch pattern processing in individuals with Autism Spectrum Disorder. It was hypothesised that there might be deficits in ‘global’ aspects of pitch pattern processing, as a result of a cognitive style known as Weak Central Coherence (Frith, 1989). This was not found using the conventional definition, where pitch contour is considered to represent a ‘global’ level of perception. However when a novel definition was adopted, evidence was obtained for a deficit in ‘global’ pitch pattern processing in this disorder. In this novel definition, ‘global’ representations result from the integration of different ‘local’ features (pitch contour, actual pitches and specific time points) to form a coherent percept. This represents a new approach to studying pitch pattern perception, which could be adopted in future investigations.

Publications Arising from Thesis

Foxton, J.M., Dean, J.L., Gee, R., Peretz, I., & Griffiths, T.D.

Characterisation of deficits in pitch perception underlying ‘tone deafness’.

Brain, 2004, 127, 801-810.

Foxton, J.M., Brown, A.C.B., Chambers, S., & Griffiths, T.D.

Training improves acoustic pattern perception.

Current Biology, 2004, 14, 322-325.

Foxton, J.M., Stewart, M., Barnard, L., Rodgers, J., Young, A.H., O’Brien, G., & Griffiths, T.D.

Absence of auditory ‘global interference’ in autism.

Brain, 2003, 126, 2703-2709.

Foxton, J.M., Talcott, J.B., Witton, C., Brace, H., McIntyre, F., Griffiths, T.D.

Reading skills are related to global, but not local, acoustic pattern perception.

Nature Neuroscience, 2003, 6(4), 343-344.

Acknowledgements

I would like to thank my supervisor Timothy D. Griffiths for all his guidance during my studies. He has been very supportive and encouraging, and has inspired me to pursue a career in this field.

I am indebted to the participants who took part in my studies. I'd like to thank the students in the autism study for persevering on our difficult tests, and the undergraduate students here at Newcastle for their participation and interest in my research. I'd especially like to thank the subjects in the congenital amusia study for their dedicated participation and enthusiasm.

Thanks are also due to undergraduate project students Hal Brace, Fiona McIntyre, Simon Chambers and Andrew Brown for their help in data collection, and for their enthusiasm on the projects. I'm also indebted to the Learning Disabilities team at Newcastle, and in particular to Mary Stewart and Louise Barnard, for help in recruiting participants for the autism study.

I'd like to express my appreciation of those I've worked with in the Auditory Group, in particular to Amanda Jennings and Rebecca Millman.

Finally, special thanks to my parents, my sister Dominique, and David Freeland for all their support and encouragement.