

**“HEY BABY! MUMMY WANTS YOU TO BE HAPPY
AND PLAY!”
THE RELATIONSHIP BETWEEN MATERNAL PITCH
CONTOURS, INFANT TEMPERAMENT AND
SYMPTOMS OF AUTISM IN INFANCY**

Alix Woolard B Psychology (Hons I)(Newcastle)

*A thesis submitted in fulfilment of the requirements for the degree of
Doctor of Philosophy*

February, 2020

*This research was supported by an Australian Government Research Training Program
(RTP) Scholarship*

Declarations

STATEMENT OF ORIGINALITY

I hereby certify that the work embodied in the thesis is my own work, conducted under normal supervision. The thesis contains no material which has been accepted, or is being examined, for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made. I give consent to the final version of my thesis being made available worldwide when deposited in the University's Digital Repository, subject to the provisions of the Copyright Act 1968 and any approved embargo.

Alix Woolard

Publications and conferences

Publications not included as part of thesis

Woolard, A. J., Benders, B., Campbell, L. E., Karayanidis, F., Mattes, J., Murphy, V. E., Whalen, O. M., Lane, A. E. (2016). Exploring the association of infant temperament on maternal fundamental frequency contours. In Sixteenth Australasian International Conference on Speech Science and Technology (pp. 229-232). Retrieved from http://www.assta.org/sst/2016/SST2016_Proceedings.pdf

ManyBabies Consortium. Quantifying sources of variability in infancy research using the infant-directed speech preference. *Advances in Methods and Practices in Psychological Science*.

Whalen, O.M., Campbell, L.E., Murphy, V.E., Lane, A.E., Gibson, P.G., Mattes, J., Collison, A., Mallise, C.A., **Woolard, A.** & Karayanidis, F. (2019). Observational study of mental health in asthmatic women during the prenatal and postnatal periods. *Journal of Asthma*, 1-13. doi: 10.1080/02770903.2019.1621888

Manuscripts in preparation

Woolard, A., Lane, A., Campbell, L. E., Karayanidis, F., Barker, D., Murphy, V. E., Whalen, O. M., Swaab, L., Benders, T. Infant and child-directed speech used with infants and children at-risk or diagnosed with Autism Spectrum Disorder: A scoping review.

Mallise, C.A., Murphy, V.E., Campbell, L.E., **Woolard, A.**, Whalen, O.M., Easey, G., Mattes, J., Collison, A., Gibson, P.G., Karayanidis, F., & Lane, A.E. Early sensory and temperament features in infants born to mothers with asthma: A cross-sectional study.

Mallise, C.A., Murphy, V.E., Karayanidis, F., Armstrong, H., Whalen, O.M., **Woolard, A.**,

Gibson, P.G., Mattes, J., Collison, A., Lane, A.E. & Campbell, L.E. A characterisation of parenting stress in mothers with asthma during the postpartum period.

Conference presentations arising from this thesis

Woolard, A., Benders, T., Campbell, L.E., Karayanidis, F., Murphy, V.E., Korostenski, L., Barker, D., Mallise, C.A., Whalen, O.M., & Lane, A.E. (*submitted*). Maternal infant-directed speech as a predictor of infant temperament.

Woolard, A., Benders, T., Campbell, L.E., Karayanidis, F., Murphy, V.E., Korostenski, L., Barker, D., Mallise, C.A., Whalen, O.M., & Lane, A.E. (*submitted*). Early autism symptoms and maternal infant-directed speech.

Woolard, A., Benders, T., Campbell, L.E., Karayanidis, F., Murphy, V.E., Korostenski, L., Barker, D., Mallise, C.A., Whalen, O.M., Mattes, J., & Lane, A.E. (*submitted*). The relationship between early autism symptoms and maternal pitch contours within infant-directed speech.

Woolard, A., Benders, T., Campbell, L., Karayanidis, F., Murphy, V., Korostenski, L., Lane, S., Barker, D., Mallise, C., Whalen, O., Tait, J., Mattes, J., Lane A. (June, 2019). The Relation between Pitch Contours in Infant-Directed Speech and Early signs of Autism in Infancy. Presented at the Australasian Society for Social and Affective Neuroscience conference 2019, Newcastle, Australia.

Woolard, A., Lane, A., Campbell, L., Karayanidis, F., Barker, D., Korostenski, L., Lane, S., Benders T. (2019, May). Characterising maternal pitch contours used during interactions with infants at high and low risk for Autism Spectrum Disorder. Poster session presented at the 177th Meeting of the Acoustical Society of America, Louisville, Kentucky, USA.

Woolard, A., Benders, T., Campbell, L., Karayanidis, F., Murphy, V., Lane, S.,

Barker, D., Mallise, C., Whalen, O., Mattes, J., Lane, A. (2019, May). The relationship between pitch contours in infant-directed speech and infant risk for autism. Poster session presented at the International Society for Autism Research 2019 Annual Meeting, Montreal, Canada.

Woolard, A., Armstrong, T., Benders, T., Lane, A., Karayanidis, F., Murphy, V., Campbell, L. The relationship between maternal infant-directed speech and infant attention during the first year. (2019, May). Poster session presented at the International Society for Autism Research 2019 Annual Meeting, Montreal, Canada.

Woolard, A., Benders, T., Swaab, L., Whalen, O., Lane, A. (2019, May). Infant-directed speech and infants who are at-risk or later diagnosed with Autism Spectrum Disorder: A scoping review. Poster session presented at the International Society for Autism Research 2019 Annual Meeting, Montreal, Canada.

Woolard, A., Benders, T., Campbell, L., Karayanidis, F., Korostenski, L., Lane, A. (2018, December). The characteristics of pitch contours in speech directed to infants at-risk for autism. Poster session presented at the Australian Society for Autism Research Annual Meeting, Gold Coast, Australia.

Woolard, A., Benders, T., Karayanidis, F., Murphy, V. E., Mallise, C., Whalen, O., Campbell, L., Lane, A. (2018, May). The characteristics of F0 contours in speech directed at infants at-risk for autism. Poster session presented at International Society for Autism Research 2018 Annual Meeting, Rotterdam, Netherlands.

Woolard, A., Benders, T., Armstrong, T., Karayanidis, F., Murphy, V. E., Mallise, C., Whalen, O., Campbell, L., Lane, A. (2018, May). The relationship between infant temperament and behaviour, and maternal infant-directed speech. Poster session presented at World Association for Infant Mental Health 2018 Congress, Rome, Italy.

Woolard, A., Benders, T., Campbell, L., Karayanidis, F., Murphy, V., Mallise, C., Whalen,

O., Lane, A. (2017, August). The effect of infant temperament on maternal infant-directed speech. Poster session presented at the meeting of the Lancaster International Conference on Infant and Early Child Development, Lancaster, UK. Retrieved from <http://wp.lancs.ac.uk/lcid/files/2017/08/Programme-booklet.pdf>

Woolard, A., Benders, T., Campbell, L., Mattes, J., Murphy, V. E., Karayanidis, F., & Lane, A. (2016, October). The association of infant temperamental characteristics on maternal pitch contours. Poster session presented at the meeting of the Centre for Brain and Mental Health Postgraduate and Postdoctoral Conference, Newcastle, Australia.

Woolard, A., Benders, T., Campbell, L., Mattes, J., Murphy, V. E., Karayanidis, F., & Lane, A. (2016, November). The association of infant temperament and maternal pitch contours. Poster session presented at the meeting of the 6th Australasian Cognitive Neuroscience Society Conference, Shoal Bay, Australia..

Other conference presentations

Lane, A.E., Van Aswegen, M., Whalen, O.M., Turner-Presker, M., Tait, J., Karayanidis, F., **Woolard, A.J.,** Mallise, C.A., Collison, A., Mattes, J., Gibson, P., Korostenski, L., Lane, S.J., Murphy, V.E., & Campbell, L.E. (*submitted*). Sensory symptoms and autism risk in infancy.

Lane, AE, Van Aswegen, M, Turner-Presker, M, Tait, J, Karayanidis, F, **Woolard, A,** Mallise, C, Whalen, O, Mattes, J, Gibson, P, Korostenski, L, Lane, SJ, Murphy, V & Campbell, L. (2019). Sensory correlates of autism risk in the first year of life: a multi-cohort study. Poster presented at the International Society for Autism Research Annual Meeting, Montreal, Canada

Mallise, C., Lane, A., Karayanidis, F., Murphy, V., **Woolard, A.,** Whalen, O. M., Campbell,

L. (May, 2018). The Trajectory of Maternal Parenting Stress and Infant Temperament across the First Year of Life. Presented at the World Association for Infant Mental Health Conference, Rome, Italy.

Whalen, O. M., Lane, A., Campbell, L., Mallise, C., **Woolard, A.**, Karayanidis, F. (August, 2017). The relationship between temperament, sensory processing and attentional control development in early infancy. Presented at the International Conference on Cognitive Neuroscience, Amsterdam, The Netherlands.

Whalen, O. M., Karayanidis, F., Mallise, C., **Woolard, A.**, Lane, A., Campbell, L. (August, 2017). The effect of infant and maternal factors on the early development of infant cognition. Presented at the Lancaster Conference on Infant and Child Development, Lancaster, England.

Permission to reproduce material under copyright

I declare that I have obtained the necessary permission from the copyright owners to use figures, tables and my own published work in cases where the copyright is held by another party. These permissions will be provided on request.

Acknowledgements

First, I would like to thank Professor Alison Lane. I consider myself extremely lucky to have had you as my primary supervisor. You have not only been a constant support for me over the past few years, but you have also been a role model, reminding me that it is possible to have a work/life balance and enjoy the little things that come our way. I aspire to be like you in my research career. To my *many* other supervisors; Dr Linda Campbell, Dr Titia Benders, Professor Frini Karayanidis, and Dr Daniel Barker, I would like to thank all of you for your individual support for me over the years. Each of you have helped in your own way, and this PhD would not have been possible if not for your help. I have learned lessons from each of you. Linda, with your compassion and ability to juggle a million things at once. Titia, you have taught me to write better with your extensive but wonderful feedback, and that what we do outside of work to take care of ourselves is just as important as the work we do. Frini, you have taught me that passion for what we do is important. And Daniel, you have taught me that statistics isn't all that scary. Having so many supervisors was hard at times, but I am extremely grateful to have experienced the spirit of collaboration during the course of this project, and I am a better researcher for it.

Thank you to all of the other researchers, students, and volunteers who helped out within the Babylab and the studies at HMRI. A special mention to Dr Olivia Whalen and (almost) Dr Carly Mallise who helped so much with the day-to-day stuff and testing the babies. A huge thanks to Gabe, Belinda, Jordan, Briana, Helen, Liv S, Taylah, Maddie, Madi, Megan, and many more student volunteers and research assistants who helped in so many ways, from data collection and entry to setting up equipment. Dr Vanessa Murphy, you have also been a huge source of compassion and support for all of us in the lab. Patricia, Kath and Kelly, thank you for helping with the BLT study and for always being ready for a chat whilst waiting for babies to arrive for their study visit.

To all of my friends at uni; Ariel, Montana, Korinne, Kaitlin, Jade, Kim, Mattsen, Patrick C, Jessie, Patrick S, Nathan, Aaron, Annie, I cannot thank you enough for being there through the good and bad. We all got through this together, and I'm sure I wouldn't have made it through so smoothly(ish) if it were not for all of you. I feel like I have made life-long friends in all of you.

To the many friends who were there to support me during this period of my life, I hope you all know how much you mean to me. A special mention to Kiz, Dani, Lina, Tom, Jackie, all the gym pals; you are such wonderful friends and I am so grateful.

To my family, thank you for being there for me through this. Brock and Riah, thank you for understanding why I sometimes couldn't see you both as often as we wanted. Troy- thank you for helping with mum, you are the best.

Angus, I can't put into words how grateful I am for everything. You have been a constant source of support, reassurance, empathy, compassion and kindness. It doesn't matter how bad the day; I feel better after being around you. I promise to be there for you when it's your turn.

A huge thank you to all of the families who took part in our research. It was because of you that this research happened. After speaking to the mothers who brought their babies in to see me, I was constantly reminded of how amazing people can be. It was the greatest pleasure to be able to watch your babies grow and play, and no study visit felt like work to me.

The biggest thank you of all goes to my mum. You are the inspiration for everything good that I do.

Preface

Mother-infant interactions are a crucial part of the early environment of an infant and they facilitate healthy development and wellbeing (Goldberg, 1988). During these reciprocal interactions, mothers and their infants influence each other in terms of their attention, affect and activity (Katz et al., 1996). Mother-infant interactions serve a socio-communicative purpose, teaching the infant how to interact with others, which is mediated via the mother's infant-directed speech (IDS). IDS is the universal speech register used by humans when interacting with infants (for a review, see Soderstrom, 2007). Extensive research has characterised the components of IDS (e.g. higher pitch). In addition, the impact of maternal characteristics such as mental health on IDS has been explored (Kaplan et al., 2015). However, relatively little attention has been given to how the infant's characteristics during these interactions impact a speaker's IDS use. This thesis focusses on the relationships between infant characteristics – specifically, temperament and early symptoms of Autism Spectrum Disorder (autism), and a component of maternal IDS; pitch contours.

Infant temperament, which refers to an infant's behavioural reactivity and regulation style, has been thought to have a profound influence on the mother-infant interaction (Rothbart & Bates, 2006). In the current thesis, it is posited that infant temperament can influence the way mothers speak to their infants. Further, as IDS facilitates infant socio-communicative and language development, the inter-relationship between IDS, infant temperament and infant socio-communication and language development is important to understand. Autism Spectrum Disorder (autism) is related to significant socio-communication and language impairment, thus early symptoms of autism in infancy are posited to influence the way mothers interact with their infant through their use of IDS.

The first chapter outlines the literature on mother-infant interactions, and how this important relationship relates to infant development. This chapter also defines IDS, and pitch

contours, and explains how they are important for infant language learning, emotional and social development. Chapter 2 outlines the infant characteristics explored in this thesis. The literature exploring the construct of infant temperament is summarized, particularly in relation to mother-infant interactions, and how this construct is likely to relate to maternal pitch contours. Autism and early symptoms of autism in infancy are then defined, and background literature regarding the interaction difficulties experienced by infants with autism symptoms is explained, which led to one of the research questions.

Chapter 3 is a scoping review of literature investigating what characterises IDS used with infants and young children either already diagnosed with autism or later diagnosed with autism. This is the first review to investigate IDS characteristics within this population, and the results of the study are discussed. Chapter 4 then outlines the gaps in the literature, which stem from the previous chapters. The research questions and aims of the thesis are also presented in chapter 4.

Chapter 5 outlines the methods used for this study, including participants, procedures used, apparatus and materials, and the data analysis procedures used. Chapters 6, 7 and 8 report the results of the study. Chapter 6 describes the study sample, the mother's IDS, and compares the infant's temperament profiles and symptoms of autism with normative data. Chapter 7 outlines the findings on how maternal pitch contours relate to infant temperament. Chapter 8 outlines the findings pertaining to the relationship of maternal pitch contours and infant autism symptoms. In Chapter 9, I discuss the results relating to maternal pitch contours and infant temperament. Followed by, Chapter 10 in which I discuss the results regarding maternal pitch contours and infant autism symptoms. To conclude, Chapter 11 includes a broad discussion of the entire study, including limitations, future recommendations, implications and general conclusions.

Abstract

Mother-infant interactions during the first year of life are crucial to healthy infant development. The communication that occurs during these interactions involves infant-directed speech (IDS), which contributes to infant language learning, social communication, and emotional development. One aspect that is useful in encouraging infant development, and arguably the most salient aspect of IDS for infants early on, is the prosodic characteristic known as pitch contours. Pitch contours relate to the trajectory of pitch. There are prototypical contours used in IDS which serve different functions like increasing infant arousal or communicating the speaker's affect. The functions of pitch contours are well known in the literature. It is less known how infant characteristics influence the use of pitch contours by mothers. Two infant characteristics known to influence mother-infant interactions are the infant's temperament and whether the infant is displaying symptoms of Autism Spectrum Disorder (autism). The aim of the current thesis was to investigate whether infant temperament and early symptoms of autism in young infants (12-months of age) were related to the pitch contours mothers used with them during an interaction.

First, a scoping review of the literature was conducted to determine if parents speak differently to infants and children who are diagnosed, or not currently but later diagnosed, with autism. Twenty-seven studies were identified as relevant, and across these studies it was concluded that infants and children diagnosed or later diagnosed with autism do not hear either more or less speech than neurotypical infants. The speech that they do hear, however, may be different in that some studies suggested parents speaking to these infants use more exaggerated acoustic features, use more directive speech, and use more attention-bids during their speech. This scoping review demonstrated the heterogeneity of methodology and results with studies investigating IDS with infants displaying autism features, and recommended more research be undertaken in this arena, which supported the work in this thesis.

Second, in a primary study investigating maternal IDS, infant temperament and infant autism symptoms, 109 mother-infant dyads were recruited from three infant development studies at the University of Newcastle BabyLab. Infant temperament was assessed via a parent-report questionnaire, the Toddler Temperament Scale (TTS; Fullard et al., 1984), given to the mothers on the day of the appointment. The TTS provided nine domain scores for the infants (activity, rhythmicity, approach, adaptability, mood, intensity, persistence, distractibility, and threshold) as well as a clinical profile (easy, intermediate low, intermediate high, and difficult). Infant autism symptoms were assessed using a parent-report questionnaire, the First Year Inventory (FYI; Reznick et al., 2007). A subset of infants ($n=26$) also received the observation-based Autism Detection in Early Childhood assessment (ADEC; Young, 2007). Infants received a FYI and ADEC total risk score, as well as a FYI social-communication and FYI sensory regulation score. The mothers' pitch contours were measured via a recorded 15-minute dyadic play interaction. 36,128 maternal pitch contours were classified into one of nine contour types (rising, bell-shaped, sinusoidal, u-shaped, flat, complex, rapidly-falling, rapidly-rising, and slowly-falling). Spearman's correlation coefficient was conducted to determine any relationships between maternal pitch contours and infant temperament and infant autism scores. Backwards elimination regressions analyses were conducted on the key variables including known covariates (infant cognitive and language skills, maternal depressive symptoms).

Infant temperament was related to maternal pitch contours. Infants rated as having a more negative mood had mothers who used more bell-shaped ($r^2=.22, p=.04$), rapidly-falling ($r^2=.27, p=.01$), and rapidly-rising contours ($r^2=.24, p=.02$). Infant distractibility was related to mothers using fewer flat contours ($r^2=.22, p=.04$). Less infant activity was related to mothers using more slowly-falling contours ($r^2=.29, p=.008$). Several models of prediction also emerged to explain variance in infant temperament scores. Infant activity scores were

predicted by the mother's use of bell-shaped, complex and slowly-falling contours, $R^2=.09$, $F(3, 81)= 3.74$, $p=.01$. Infant rhythmicity scores were predicted via the mother's depressive symptoms and sinusoidal contours, as well as the number of days the infant was born preterm, $R^2=.19$, $F(3, 74)= 4.94$, $p=.004$. Infant adaptability was predicted by the mother's depression symptoms, and her use of sinusoidal and rapidly-falling contours, $R^2= .12$, $F(3, 44)= 3.04$, $p=.04$. Infant intensity scores were predicted by the number of days the infant was born preterm and the mother's use sinusoidal contours. Finally, the infants' mood scores were predicted by the number of days preterm the infant was and also the mother's use of rapidly-falling contours, $R^2=.12$, $F(2, 85)= 6.91$, $p=.002$.

Infant autism symptoms were also related to maternal pitch contours. Mothers used fewer sinusoidal contours when their infant displayed more autism symptoms ($r^2=-.30$, $p=.004$) and more autism-related sensory regulation issues ($r^2=-.31$, $p=.001$). Mothers also used fewer flat contours if their infant displayed more autism symptoms ($r^2=-.39$, $p=.04$). Again, several models of prediction emerged from the key study variables that explained variance in infant autism symptoms. Infant FYI total score was predicted via the mother's depression symptoms and number of utterances she used during the interaction, as well as the infant's cognitive score on a developmental assessment, $R^2=. 34$ $F(3, 47)= 9.58$, $p<.0001$. Infant social communication score on the FYI was predicted by the mother's depression score as well as the number of utterances she spoke and her use of flat contours, $R^2=.28$ $F(3, 47)= 7.46$, $p=.0003$. Infant sensory regulation score on the FYI was predicted by the mother's depressive symptoms, and her rising and sinusoidal contours as well as the infant's cognitive score on a developmental assessment, $R^2=.20$ $F(4, 46)= 4.22$, $p=.005$. Finally, the infants' score on the ADEC was predicted by the mother's rising, bell-shaped, flat and complex contours as well as the infant's language skills, $R^2=.70$ $F(5, 20)= 12.48$, $p<.0001$.

This thesis provides the first evidence that maternal pitch contours are related to infant temperament and early autism symptoms in infancy. The functions thought to underpin the relationships between the infant characteristics and the maternal pitch contours are discussed in detail. These results support the theory that mother-infant interactions are bidirectional, with both the mother and the infant playing active roles. Further research into mother-infant interactions, IDS, pitch contours and the influence of infant characteristics is recommended. These results could inform or support early parent-training interventions involving the use of IDS to target early relationship, language, socio-communication difficulties, as well as improving the outcomes of infants displaying autism symptoms.

Abbreviations

Table 1. Abbreviations as they appear in the thesis

Relating to infant characteristics	
IDS	Infant-directed speech
Autism	Autism Spectrum Disorder
ASD	Autism Spectrum Disorder
HR	High-risk
LR	Low-risk
LDA	Later diagnosed with autism
CDS	Child-directed speech
ADS	Adult-directed speech
TD	Typically-developing
Experimental	
NYLS	New York longitudinal study
CTS	Carey Temperament Scales
PVR	Parental verbal responsiveness
MLU	Mean length of utterance
F0	Fundamental frequency (pitch)
dB	Decibel
HSJE	Higher level supported joint engagement
LSJE	Lower level supported joint engagement
BLT-ID	Breathing for life – infant development study
BLT	Breathing for life trial
BM	BabyMinds

SDPrem	Sensory modulation in preterm infants' study
RCT	Randomised control trial
HMRI	Hunter Medical Research Institute
JHCH	John Hunter Children's Hospital
NICU	Neonatal Intensive Care Unit
CAP	Clinical applications portal
TTS	Toddler Temperament Scale
ADEC	Autism Detection in Early Childhood
FYI	First Year Inventory
ADOS	Autism Diagnostic Observation Schedule
EPDS	Edinburgh Post-Natal Depression Scale
BSID-III	Bayley Scales of Infant and Toddler Development – Third Edition
Hz	Hertz
SE	Standard error

Table of contents

Declarations	2
Publications and conferences	3
Publications not included as part of thesis.....	3
Manuscripts in preparation	3
Conference presentations arising from this thesis	4
Acknowledgements.....	8
Preface.....	10
Abstract.....	12
Abbreviations.....	16
Table of contents.....	18
Chapter 1: Maternal interactive behaviours and characteristics	24
1.1 Mother-infant interactions	24
1.2 Infant-Directed Speech	26
1.2.1 Pitch contours	29
Chapter 2: Infant interactive behaviour and characteristics.....	33
2.1 Infant Temperament.....	33
2.2 Autism.....	39
2.2.1 Infants showing early signs of autism	39
2.2.2 Temperament in autism	41
2.2.3 Social interactions and autism	42

Chapter 3: Infant and child-directed speech used with infants and children at-risk or diagnosed with Autism Spectrum Disorder: A scoping review.....	44
3.1 Infant-directed speech.....	44
3.2 Autism in early infancy.....	47
3.3 Method.....	48
3.3.1 Identifying relevant studies.....	49
3.4 Results and Discussion.....	51
3.4.1 General characteristics of included studies.....	51
3.4.2 Frequency of speech and/or IDS.....	65
3.4.3 Acoustic features.....	68
3.4.4 Mean length of utterances (MLU).....	69
3.4.5 Complexity of IDS and language input.....	70
3.4.6 Content: General content.....	70
3.4.7 Content: Use of questions.....	72
3.4.8 Content: Attention regulating characteristics.....	72
3.5 General Discussion.....	76
Chapter 4: Research gaps.....	80
4.1 The current study.....	81
Chapter 5: Methods.....	82
5.1 Participants.....	82
5.1.1 BLT-ID.....	84
5.1.1.1 Breathing for Life Trial (BLT).....	85

5.1.2 BM.....	86
5.1.3 Sensory Development Following Prematurity study (SDPrem).....	87
5.1.4 The current sample: Demographic information.....	88
5.2 Procedure	91
5.2.1 Recorded play interaction.....	92
5.2.2 Infant temperament.....	92
5.2.3 Autism Measures	94
5.2.3.1 Autism questionnaire.....	94
5.2.3.2 Autism observational assessment	95
5.2.4 Covariate measures.....	96
5.2.4.1 Sociodemographic questions	96
5.2.4.2 Edinburgh Post-Natal Depression Scale.....	98
5.2.4.3 Developmental assessment.....	98
5.3 Apparatus	100
5.4 Acoustic Analyses.....	101
5.5 Statistical Analyses	102
5.5.1 Aim 1: The relationship between infant temperament and maternal pitch contours at 12 months.....	103
5.5.2 Aim 2: The relationship between infants displaying early signs of autism and maternal pitch contours at 12 months.....	103
Chapter 6: Descriptive Results and Preliminary Analyses	105
6.1 Descriptive statistics: Maternal IDS	105

6.2 Checks for multi-collinearity in key variables.....	109
6.3 Maternal covariates.....	112
6.4 Infant covariates.....	112
6.5 Descriptive statistics: Temperament.....	115
6.6 Descriptive statistics: Autism	117
Chapter 7: Relationship between IDS and temperament.....	119
7.1 Infant temperament and maternal pitch values and utterances at 12 months	119
7.1.2 TTS domain scores and maternal pitch contours.....	119
7.2 TTS profile scores and maternal pitch contours	123
7.3 Regression model for the TTS domain scores and maternal pitch contours	123
7.3.1 Infant activity.....	123
7.3.2 Infant rhythmicity	124
7.3.3 Infant adaptability.....	125
7.3.4 Infant intensity.....	125
7.3.5 Infant mood.....	126
Chapter 8: Relationship between IDS and autism symptoms.....	127
8.1 Infant FYI scores and maternal pitch values and utterances	127
8.2 Infant FYI scores and maternal pitch contours.....	128
8.3 Infant ADEC scores and maternal pitch values and utterances.....	129
8.4 Infant ADEC scores and maternal pitch contours	129
8.5 Regression model for the infant FYI scores and maternal pitch contours.....	130

8.5.1 Infant FYI total score.....	130
8.5.2 Infant FYI social communication score.....	131
8.5.3 Infant FYI sensory regulation score	131
8.5.4 Infant ADEC score	132
Chapter 9: Discussion of the relationship between infant temperament and maternal pitch contours.....	
9.1 Interpretation of findings	134
9.1.1 Rapidly-rising contours	135
9.1.2 Slowly-falling contours	136
9.1.3 Bell-shaped contours	136
9.1.4 Other findings of interest.....	137
9.1.4.1 Flat contours	137
9.1.4.2 Sinusoidal contours.....	138
9.1.5 Maternal depression and preterm status as covariates.....	139
9.2 Limitations	140
9.3 Summary and Future considerations.....	142
Chapter 10: Discussion of the relationship between autism and maternal pitch contours.....	
10.1 Interpretation of findings	145
10.1.1 Sinusoidal contours.....	145
10.1.2 Number of Utterances.....	146
10.1.3 Flat contours	148
10.1.4 Depression in mothers	149

10.1.5 Interpretation of null findings.....	150
10.2 Limitations	151
10.3 Summary and future considerations	151
Chapter 11: General discussion and conclusions.....	153
11.1 General limitations of the study and future recommendations.....	156
11.2 Implications and conclusions.....	157