January 2012

Intonation Perception In Elderly And Young Adult Subjects

Afua Mmra Blay

INTONATION PERCEPTION IN ELDERLY AND YOUNG ADULT SUBJECTS

by

Afua Mmra Blay
Bachelor of Arts, University of Ghana, 2007

A thesis
Submitted to Graduate Faculty

of the

University of North Dakota

in partial fulfilment of the requirements

for the degree of

Master of Science

Grand Forks, North Dakota
May
2012

This thesis submitted by Afua Mmra Blay in partial fulfilment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done, and is hereby approved.

Dr. Amebu Seddoh

_____

Dr. Wayne Swisher

_____

Dr. Richard Ferraro

_____

This thesis is being submitted by the appointed advisory committee as having met all of the requirements of the Graduate School at the University of North Dakota and is hereby approved.

Dr. Wayne Swisher

_____

Dean of the Graduate School

April 25, 2012

_____

Date

Title Intonation Perception in Elderly and Young Adults Subjects

Department Communication Sciences and Disorders

Degree Master of Science

In presenting this thesis in partial fulfilment of the requirements for a graduate degree from the University of North Dakota, I agree that the library of this University shall make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my thesis work, or, in his absence, by the Chairperson of the department or the dean of the Graduate School. It is understood that any copying or publication or other use of this thesis or part thereof for financial gain shall not be allowed without written permission. It is also understood that due recognition shall be given to me and to the University of North Dakota in any scholarly use which may be made of any material in my thesis.

Afua Mmra Blay
April 25, 2012

TABLE OF CONTENTS

LIST OF FIGURES

Figure Page

LIST OF TABLES

Table Page

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to God for seeing me through this project. I would also like to thank my advisor, Dr. Seddoh and my committee members Dr. Ferraro and Dr. Swisher for their guidance. To all participants, I say a big thank you for making this study possible. I appreciate everyone who contributed to this study in one way or the other.

ABSTRACT

Various studies have reported that elderly individuals have difficulty perceiving intonation, especially in emotional context. However, the nature and the extent to which this problem affects the communication ability of these individuals are poorly understood. Most studies use isolated sentences which unlike natural discourse indicate no contextual information. Consequently, it is unclear whether the intonation processing problems for the elderly are manifested across the board regardless of availability of contextual information. To understand this issue, the present study sought to compare the performance of elderly adults on perception of intonation in stimuli presented with and without contextual information. Participants were 20 elderly and 26 young adults. They were presented two categories of sentences that conveyed emotional (happy vs. sad) and nonemotional (statement vs. question) distinctions. Each emotional stimulus was presented with and without contextual information, and subjects were required to identify its meaning. The nonemotional sentences were presented without contextual information and subjects were asked to indicate whether each was a statement or a question. Elderly adults performed on both tasks comparably with the young subjects. However, they had difficulty identifying sad meanings presented without contextual information. These outcomes were discussed in terms of factors that influence perception of emotional meanings in discourse. It was suggested that the failure of the elderly subjects to recognize sad meanings presented without contextual information might have a basis in the acoustic properties of the stimulus.

CHAPTER I

INTRODUCTION

Intonation refers to suprasegmental pitch variations in spoken language (Lehiste, 1970). It is suprasegmental in the sense that it extends beyond a single segment. Intonational pitch variations span over whole utterances such as sentences (e.g.,I saw the woman) and phrases (e.g.,The tall man) and they convey "postlexical" pragmatic meanings (Ladd, 1996). Intonation also functions to convey grammatical distinctions such as the difference between declaratives (e.g.,He stole the money*)* and their matched echo questions *(e.g.,*He stole the money?), as well as emotional (e.g., happy and sad) and attitudinal (e.g., rudeness) meanings.

Studies of intonation perception and production are limited (see Cutler, Dahan & Donselaar, 1997 for a review). Some findings are that intonation is acquired relatively early by children (e.g., Loeb & Allen, 1993) but its processing declines with age (Allen & Brosgole, 1993). Before they are one and half years old, children have control over core aspects of intonation and produce it with adult-like proficiency (Marcos, 1987; Snow, 2006). Data indicate also that the ability to process intonation is maintained until around middle age when it begins to decline (e.g., Brosgole & Weisman, 1995). Paulmann, Pell and Kotz (2008) compared young and middle aged subjects' ability to perceive intonation in emotional context and found that the young adults outperformed the middle aged participants.

A related finding that has received some attention in recent years is that older adults perform poorer compared to younger adults on tasks involving intonation in not only emotional (Kiss & Ennis, 2001; Mitchell 2007) but also nonemotional (Allen & Brosgole, 1993; Mitchell, Kingston & Barbosa Bouças, 2011; Taler, Baum & Saumier, 2006) contexts. For instance, Allen and Brosgole (1993) found that older adults were outperformed by younger adults on tasks involving identification of intonation in both contexts. Similar results were reported by Mitchell, Kingston & Barbosa Bouças (2011) who compared the performance of older and younger adults on tasks involving low-pass filtered and semantically neutral stimuli in emotional and nonemotional contexts.

The basis of these findings is unclear. Although factors such as depression, reduced attentional control, verbal memory and hearing loss have been suspected, there is lack of strong evidence that they are directly linked to the problem (Mitchell 2007; Orbelo, Grim, Talbott, & Ross 2005). For instance, Mitchell (2007) controlled for some of these factors by, among others, excluding subjects with psychiatric or neurological disorders, and taking into account the participants' levels of verbal working memory and IQ. The experimental task involved reliance on intonation to label a semantically neutral sentence with emotional meanings. Results showed that compared to younger adults, the geriatric subjects had notable difficulties, suggesting a deficit that may be independent of sensory and related factors.

Some studies suggest that both younger and older adults rely on lexico-semantic information during performance on tasks involving intonation perception (e.g. Kiss & Ennis, 2001; Raithel & Hielscher-Fastabend, 2004). However, attempts to explore the

question whether older adults rely more on this information compared to younger adults have yielded mixed results. For example, Kiss and Ennis (2001) found that older adults performed significantly poorer compared to younger adults on an intonation processing task involving nonsense phrases but the performance improved on tasks that had lexical content. Dupuis and Pichora-Fuller (2010), on the other hand, failed to find evidence that geriatric individuals rely mainly on lexico-semantic cues during performance on tasks involving intonation perception.

One possibility that has a potential to shed light on the source of the difficulties experienced by the geriatric subjects during performance on intonation processing tasks has to do with contextual information. Discourse comprehension in everyday communication depends largely on its context (Bransford & Johnson, 1972; Glucksberg, Kreuz & Rho, 1986). Contextual information is especially important in the recognition of emotions (Barrett, Lindquist & Gendron, 2007). Cauldwell (2000) found that young adults benefited from contextual information when they were asked to decide whether a wh- question conveyed anger or not. The subjects had difficulty identifying emotion in utterances in isolation but they performed better when contextual information was provided. Richter, Dietzel and Kunzmann (2010) also compared the performance of older and younger women on emotion recognition tasks that involve reliance on visual and verbal contextual cues in a video clip in which discrete emotions were described. The performance of both groups was comparable when judgement was based on verbal context but it declined when it was based solely on visual cues.

These results suggest that successful verbal emotional communication may depend on contextual information. However, the validity of this possibility and the extent to which it is generalizable across channels of verbal emotional communication such as intonation are unclear. Studies typically focus on intonation itself rather than factors that influence its production or perception. Consequently, there is paucity of comparative data on intonation tasks that include or exclude contextual information.

Related investigations including functional magnetic resonance imaging (fMRI) data (see, for example, D'Esposito, 1999; Grady, 2000; Roalf, Pruis, Stevens, & Janowsky, 2011) indicate that elderly subjects have reduced limbic system, particularly amygdala response during performance on emotion recognition tasks, and that they compensate for this deficit by relying on cognitive/linguistic information (Tessitore, Hariri, Fera et al., 2005). Thus, these individuals might perform poorly relative to young adults on identification of emotional meanings signalled by intonation in stimuli presented with or without contextual information. On the other hand, their performance on identification of nonemotional meanings signalled by intonation in these stimulus types might be comparable to that of young adults. This combination of outcomes will point to emotional processing deficit as the basis of the poor performance of the elderly on tasks involving reliance on intonation to identify emotional meanings signalled by intonation. However, it is possible that the ability to process intonation itself also diminishes with age (Allen & Brosgole, 1993; Raithel & Hielscher-Fastabend, 2004; Taler, Baum & Saumier, 2006). If this is so, then outcomes for the elderly might fall below those of young adults across the board regardless of intonation function and mode

of stimulus presentation, and they might be poorer for the task involving identification of emotional compared to nonemotional meaning.

The present study sought to evaluate the comparative ability of elderly adults to identify emotional versus nonemotional meanings signalled by intonation in stimuli presented with and without contextual information. The objective was to determine whether difficulties experienced by these subjects on such tasks are attributable to primary emotional and/or intonation processing deficit. The following specific questions were explored.

1) Does contextual information influence ability to identify meanings signalled by intonation irrespective of age?

2) Do elderly adults rely more on contextual information to identify meanings signalled by intonation compared to younger adults?

3) Do elderly adults perform differentially on identification of meanings conveyed by intonation in stimuli presented with and without contextual information?

CHAPTER II

LITERATURE REVIEW

Intonation in Children

Evidence suggests that intonation develops early relative to other aspects of language (Mehler et al., 1988; Snow & Balog, 2002; Walker-Andrews & Grolnick, 1983). The ability to process it has also been reported to reach an asymptote around age 12 and to begin declining around mid-age (Brosgole & Weisman, 1995).

Some studies reported that infants rely on acoustic cues including, perhaps, those related to intonation to identify their mother's voice (e.g., DeCasper & Fifer, 1980) and to discriminate rising and falling contours (Nazzi, Floccia & Bertoncini, 1998). Mehler et al. (1988) similarly found that four-day-old French and 2-month-old North American infants were able to distinguish utterances in their native languages from other languages based on prosodic cues. Other reports indicate that children produce adult-like intonation patterns in the late babbling stage (Dore, 1975; Lenneberg, 1967).

By six months, children are able to use varied intonation contours to convey pragmatic intent. D'Odorico (1984) reported that their 4-8 month old subjects were able to communicate requests using non-cry vocalizations that have rising or level pitch patterns whereas they signal discomfort with falling patterns. Walker-Andrews and Grolnick (1983) also found that infants as young as 5 months old can discriminate between sad and happy vocal expressions.

In the first year of life, the most frequent intonation pattern is falling tone (e.g. Kent & Bauer, 1985; Delack & Fowlow, 1978). This intonation pattern is used by children as a boundary marker (Snow & Balog, 2002). Morton and Trehub (2001) found that 4-year old English speaking children who had not been exposed to Italian were able to identify emotion conveyed by intonation in Italian sentences. Tonks, Williams, Frampton, Yates and Slater (2007) reported that 9-15 year old children performed almost equally well on various tasks including discrimination between statements and questions based on intonation pattern, as well as identification and discrimination of emotions conveyed by intonation. This finding is consistent with the view that the ability to process intonation plateaus at about age 12 (Brosgole & Weisman, 1995).

Intonation in Adults

Some studies suggest that the ability to process intonation in nonemotional context remains intact presumably throughout the life span. Taler, Baum and Saumier (2006) reported that their elderly participants exhibited no difficulty in distinguishing statements from questions by relying on intonation. On the other hand, they had difficulty judging low-pass filtered sentences that signal commands. The latter outcome may be related to naturalness. Communication in natural discourse involves reliance on not only suprasegmental, but also segmental information (e.g., Cutler, 1977). Because perceptual stimuli that are low-pass filtered lack segmental content, they might be difficult to process regardless of age (e.g., Raithel, Hielscher-Fastabend, 2004).

Other studies suggest that the ability to perceive intonation in nonemotional speech declines with age (Allen & Brosgole, 1993; Mitchell & Kingston, 2011; Mitchell, Kingston & Barbosa Bouças, 2011). Allen and Brosgole (1993) asked young and elderly subjects to judge sentences as commands, statements or questions. They found a significant deficit in the performance of the elderly compared to the young subjects. Mitchell and Kingston (2011) also reported that young subjects outperformed their adult counterparts in determining whether stimuli administered auditorily were statements, questions or neither. In a similar study, Mitchell, Kingston and Barbosa Bouças (2011) found that compared to young subjects, elderly adults were less accurate in identifying sentences that conveyed grammatical information, particularly questions.

Thus, findings of studies of intonation perception in nonemotional speech on elderly subjects are mixed. This is unlike the case for studies of intonation in emotional speech on this population. Many of these studies found that elderly individuals perform poorly on the identification of emotional meanings signaled by intonation. For example, Allen and Brosgole (1993) presented young and elderly subjects with pre-recorded sentences conveying emotional meanings. The subjects were required to identify emotions verbally and by pointing to drawings of faces. Results showed that the elderly subjects performed poorly compared to their young counterparts on both tasks. Similarly, Mitchell et al. (2011) asked their elderly and young subjects to identify happy and sad meanings conveyed by intonation in sentences. They found that the elderly subjects performed poorly compared to the young participants.

Some studies also indicate that elderly adults have more difficulty processing negative compared to positive emotions signaled by intonation (Brosgole & Weisman, 1995; Mitchell, Kingston & Bouças, 2011; Ryan, Murray & Ruffman, 2010). However, this finding is not consistent across different studies. For example, Ryan, Murray & Ruffman (2010) asked their elderly and young subjects to identify emotions conveyed by vocalizations and simple sentences. They found that elderly subjects showed worse performance on sadness and anger relative to happiness and surprise. Of the negative emotions, the perception of fear and disgust was easier in comparison to sadness and anger. Similarly, the elderly subjects evaluated by Brosgole and Weisman (1995) exhibited more difficulty with identification and discrimination of anger and sadness compared to happiness. In contrast to these data, Ruffman et al. (2008) found that their elderly subjects exhibited difficulty on identification of happy emotions signaled by intonation.

Age-related hearing loss has been implicated as a factor in the difficulties experienced by elderly adults in language processing in general (Murphy, Daneman, & Schneider, 2006 ; Schneider, Daneman, Murphy & Kwong See, 2000; Schneider, Daneman & Pichora-Fuller, 2002). For example, the elderly adults evaluated by Schneider and colleagues (2000) had some high-frequency hearing loss. Compared to young listeners, they performed poorly at recalling details of a verbal monologue in either quiet or noisy environments. However, some studies failed to find evidence that the problems for the elderly in intonation perception are specifically attributable to hearing loss (e.g., Mitchell 2007; Orbello, Grim, Talbott, & Ross, 2005). In one study, Mitchell et

al. (2011) assessed the effect of hearing sensitivity by comparing the performance of subjects with high and low hearing sensitivities. They found that hearing sensitivity did not have an effect on the subjects' performance. Studies that have excluded subjects with hearing loss have also reported similar findings (e.g., Dupuis & Pichora-Fuller, 2010).

Another explanation for the intonation processing problems for the elderly has to do with lexico-semantic information. Mitchell, Kingston and Barbosa Bouças (2011) hypothesized that concurrent processing of lexico-semantic content and intonational cues could make it difficult for elderly adults to perceive pragmatic intent from sentences. To test this hypothesis, these investigators asked their elderly and young subjects to identify emotions, as well as questions and statements from sentences with intact lexico-semantic information and low-pass filtered sentences. The elderly adults performed poorer on the sentences with intact lexico-semantic information, suggesting that they might have experienced difficulty in processing this (lexico-semantic) information and intonation simultaneously. Similarly, Dupuis and Pichora-Fuller (2010) presented young and elderly adults with sentences in which the intonation contour and lexico-semantic content were either congruent or incongruent. They reported that on tasks in which lexico-semantic information conflicted with intonation contour, younger adults seemed to rely on the intonation contour to judge the emotion conveyed. Elderly adults on the other hand, were not consistent in relying on one or the other information.

Primary emotion processing deficit may also account for the difficulties exhibited by the elderly in identifying emotional meanings conveyed by intonation. Elderly adults have difficulty perceiving emotion in not only verbal (Brosgole & Weisman, 1995;

Mitchell, Kingston & Barbosa Bouças, 2011; Ryan, Murray & Ruffman, 2010) but also visual (e.g., Mill, Allik, Realo & Valk, 2009; Philips, MacLean & Allen, 2002) domains. Some studies found that elderly subjects were impaired in the ability to identify facial expressions of emotions from photographs (Calder et al., 2003) and pictures (Philips, MacLean & Allen, 2002). Taken together, these data suggest that the underlying problem for elderly subjects might be primarily related to emotional processing.

Evidence suggests that lower level auditory perceptual problems may also account for the deficit exhibited by elderly adults on tasks involving perception of intonation. Taler et al. (2006) found that these individuals perform poorly on tasks involving reliance on temporal information to make syntactic and lexical judgements. They investigated perception of lexical stress in a group of elderly adults. They asked the subjects to differentiate between compound words (greenhouse) and their matched noun phrases (green house). Elderly adults performed poorly on the task, suggesting that their difficulty might be related to aspects of the signal such as fundamental frequency, duration and intensity, which are the acoustic correlates of stress and intonation (Lehiste, 1970).

One problem with the literature is both methodological and theoretical in nature. It is assumed that the suprasegmental components of an utterance constitute an independent communication channel. This is regardless of whether the meaning it conveys is congruent or incongruent with that signaled by the text. Consequently, some studies used meaningless utterances (e.g. Kiss & Ennis, 2001) and low-pass filtered sentences to investigate intonation perception (e.g., Orbelo et al., 2005). Low-pass filtered sentences are created by removing higher frequencies on which word recognition

depends from the stimuli (Kramer, 1963; Rogers et. al, 1971). This type of stimuli is believed to represent 'pure' intonation and therefore best measures the performance of subjects (Mitchell et al., 2011). However, as noted above, these stimuli are unnatural, which may be why subjects perform poorly on them (e.g., Raithel & Hielscher-Fastabend, 2004).

In summary, the literature suggests that the ability to perceive intonational meanings develops and reaches an asymptote around 12 years, and it starts declining by mid-age (Brosgole & Weisman, 1995). For elderly adults, some studies suggest that the ability to process intonation in nonemotional context remains intact (Taler, Baum & Saumier, 2006) whereas others suggest that it declines with age (Allen & Brosgole, 1993; Mitchell & Kingston, 2011; Mitchell, Kingston & Barbosa Bouças, 2011). In contrast to these data, studies on perception of intonation in emotional context on this population have consistently reported a decline in this ability (e.g., Mitchell & Kingston, 2011; Mitchell, Kingston & Barbosa Bouças, 2011). Various explanations have been suggested to account for the deficit including age-related hearing loss and difficulty processing acoustic and lexico-semantic information simultaneously. However, some studies failed to find evidence in support of these possibilities.

CHAPTER III

METHOD

Subjects

Forty-six healthy native speakers of English participated in the study. They were made up of 26 elderly and 20 young adults (mean age 21). The elderly subjects were aged between 65 and 89 years (mean age 76). They were recruited from a volunteer list of individuals who participated in previous studies by Drs. Ferraro and Seddoh. The young adults were aged between 21 and 27 years. They were undergraduate students at University of North Dakota. They were randomly selected across various departments or majors.

Young subjects underwent a pure-tone air conduction test bilaterally at 30dBHL for 1000Hz, 2000Hz and 4000Hz to assess their hearing abilities. The test was done in a sound treated room using a GSI 38 Auto Tymp portable audiometer. 6 out of the 20 elderly subjects failed the hearing screening. To assess the effect of hearing sensitivity on subject' performance, subjects who failed the test were included in the study.

Subjects with a history of language, neurological or cognitive deficits were excluded from the study. Subjects who had visual problems that could potentially interfere with their performance of the experimental tasks were also excluded. Both inclusionary and exclusionary criteria were determined from self-reports.

Stimuli

The stimuli consisted of two sets of sentences that convey either emotional or non-emotional meanings. Each stimulus set was made up of syntactically simple English sentences that have either a subject-verb-object word order (e.g. *Dora saw the lady*) or an adverbial phrase (e.g. *Sally is in the room*). The sentences ranged from four to eleven syllables in length. The emotional sentences conveyed either a happy or a sad meaning. There were 25 sentences with happy meanings and 25 sentences with sad meanings. The non-emotional stimuli were made up of 25 statements (e.g. *He lost the money*) and 25 matched echo questions (*He lost the money?*).

Stimulus Preparation

Each sentence was produced by a native speaker of English. The productions were recorded in a quiet setting using a Martel HGM-1 HiGain Microphone. Signal from the microphone was passed to a Rolls MiniMix IV mixer. The mixer's output served as an input to a WavePad Sound Editor 4.52 program implemented on a Dell Optiplex GX 260 computer. The WavePad Sound Editor made it possible to digitize and store the signal on the computer, as well as display and play it back through a pair of harman/kardon loudspeakers connected to the computer. Artefacts such as pops and clicks could also be identified and removed.

For each emotional sentence, contextual information was provided as exemplified in Table 1. These sentences were recorded with and without the contextual information. Thus, two sets of emotional stimuli made up of 50 sentences with contextual information

(25 happy and 25 sad meanings) and 50 sentences without contextual information (25 happy and 25 sad meanings) were generated. The sentences in both sets of stimuli were produced by a male speaker. The contextual information for each sentence that has it was produced by a female speaker. This was done after the production of the sentence by the male speaker. All of the nonemotional sentences were produced by the male speaker only. No contextual information was provided for these sentences.

The recorded stimuli were edited using the WavePad Sound Editor. The editing of the emotional stimuli involved random mixing of sentences conveying happy meanings with those conveying sad meanings. Statements and questions, the nonemotional stimuli, were similarly randomized. In addition to the randomization, interstimulus interval was made uniform by inserting gaps of 1600 ms between consecutive sentences in each stimulus set. All stimuli were then tape recorded from the computer using a DA-PI portable tape recorder.

To ensure that the stimuli signal reliably the intended meanings, they were played from the tape recorder to a group of 33 undergraduate students, who were also native speakers of English to judge. There was 100% agreement among the judges on the meanings conveyed by the emotional sentences that were provided contextual information. By contrast, there were disagreements on the interpretations of some of the emotional sentences that were provided no contextual information. Ten judges (30%) had different interpretations for 10 sentences intended to convey sad meanings. Five sentences intended to convey happy meanings were also interpreted differently by 7 (21%) judges. Thus, the overall interjudge agreement was 70% for sentences conveying

sad meanings and 79% for sentences conveying happy meanings. The judges demonstrated 97% agreement on identification of statements in the nonemotional stimulus set. By contrast, 5 questions in this stimulus set were identified as statements by 5 (15%) of the judges, making the overall interjudge agreement for these constructions 85%.

All of the sentences on which some of the judges had disagreement were replaced with new ones. The replacements were prepared the same way as the original stimuli. One exception, however, was an increase in the interstimulus interval from 1600 ms to 3000 ms. Although the young judges had no problem with the shorter interstimulus interval (1600 ms), two elderly individuals who also listened to the stimuli found it too short. The prepared stimuli were evaluated by five new judges. There was a 100% on their authenticity. The full list of stimuli used in the study is shown in Appendix A.

Procedure

The prepared stimuli were presented to subjects auditorily by playing them from the computer through loudspeakers. The presentation was conducted in a quiet setting in one session. Before the presentation of the stimuli without contextual information, subjects were told that the experiment was intended to understand how listeners process emotional meanings in speech, and that their task is to determine for each sentence whether the speaker was happy or sad. In the case of emotional sentences with contextual information, subjects were instructed to base their judgments on the productions by the male speaker and the contexts provided by the female speaker. Prior to the presentation

of the non-emotional stimuli, subjects were told that the objective of the experiment is to understand how listeners differentiate statements from questions, and that their task is to identify each sentence type produced by the speaker. Emotional sentences without contextual information were presented prior to the presentation of their counterparts with contextual information. On the other hand, the order of the presentation of the other stimulus categories was random. Thus, for some subjects the first task was the identification of meanings conveyed by emotional sentences that were provided no contextual information. For others, it was the distinction between statement vs. question in the nonemotional stimulus set.

Subjects were provided response sheets on which to indicate their judgments. For each sentence in each task, three options were provided on the response sheet as follows: Happy, Sad and Not sure (for both categories of emotional stimuli), and Statement, Question and Not sure (for the nonemotional stimuli). Subjects were asked to underline or circle the option that best characterized the male speaker's feeling or intent in each sentence.

Table 1. Emotional stimuli with contextual information

Stimuli	**Intended Emotion**	**Context**
Dora saw the lady	Happiness	She was her childhood friend.
Henry was at the hockey game	Sadness	He was there when the boy was shot.

CHAPTER IV

RESULTS

All participants except six elderly subjects exhibited normal outcomes on the hearing screening. It is not entirely clear whether age-related hearing loss affects ability to perceive distinctions signaled by intonation. Whereas some studies indicate that this might be the case (e.g., Fransen et al., 2003), others found no evidence in support of this possibility (e.g., Mitchell et al., 2011). In order to be sure, the six individuals who exhibited abnormal outcomes on the hearing screening were also tested on the experimental tasks. However, their data were separated from those of the elderly subjects who had normal hearing. Thus, there was one set of data for the elderly subjects who passed the hearing screening and another for those who failed. The data set for those with normal hearing acuity was labeled Elderly 1 and that for those with abnormal hearing acuity was labeled Elderly 2. The two data sets were then compared across all measures. Table 2. displays the mean and the standard deviations for each measure for the Elderly 1 and the Elderly 2 groups. No significant difference was found between these groups on measures in the nonemotional [$F(1, 17) = .596$, $p = .562$] or the emotional [$F(1, 15) = 1.56$, $p = .235$] stimulus category, consistent with previous findings (e.g., Mitchell et al., 2011).

Table 2. Comparative data for elderly subjects with normal hearing ability (Elderly1) and hearing loss (Elderly 2).

Stimuli		Subject Group	Mean	Standard Deviation	P Value
Category	Type				
Nonemotional	Question	Elderly1 ---------- Elderly2	95.7143 ---------- 98.6667	6.92186 ---------- 3.26599	.337
	Statement	Elderly1 ---------- Elderly2	98.5714 ---------- 99.3333	2.53329 ---------- 1.63299	.509
Emotional	Sad1	Elderly1 ---------- Elderly2	90.8571 ---------- 92.0000	11.36024 ---------- 11.59310	.840
	Sad2	Elderly1 ---------- Elderly2	98.2857 ---------- 95.3333	3.40652 ---------- 5.31664	.150
	Happy1	Elderly1 ---------- Elderly2	92.5714 ---------- 94.6667	9.65333 ---------- 7.86554	.646
	Happy2	Elderly1 ---------- Elderly2	97.0714 ---------- 96.0000	7.40545 ---------- 5.05964	.752

Note: Sad1= Sentences conveying sad meanings presented without contextual information; Sad2= Sentences conveying sad meanings presented with contextual information; Happy1= Sentences conveying happy meanings presented without contextual information; Happy2=Sentences conveying happy meanings presented with contextual information.

In view of this outcome, the two data sets were collapsed into one, and no distinction was made between the elderly subjects who passed or failed the hearing screening. The combined data were compared with those for the young adults. Table 3. displays the means and the standard deviations for the identification of each stimulus type by the elderly and the young adult groups. In absolute terms, the performance of the

elderly adult group fell below the outcomes for the young group across all measures in both stimulus categories. ANOVA results are presented below for each stimulus category.

Table 3. Identification of emotional and nonemotional meanings by young and elderly subjects

Stimuli		Subject Group	Mean	Standard Deviation
Category	Type			
Nonemotional	Question	Young ---------- Elderly	99.0769 ---------- 96.6000	2.34816 ---------- 6.12501
	Statement	Young ---------- Elderly	99.2308 ---------- 98.8000	1.96586 ---------- 2.28496
Emotional	Sad1	Young ---------- Elderly	97.6923 ---------- 91.2000	3.78174 ---------- 11.13364
	Sad2	Young ---------- Elderly	98.1538 ---------- 97.4000	4.26795 ---------- 4.15996
	Happy1	Young ---------- Elderly	96.3077 ---------- 93.2000	5.41678 ---------- 9.00058
	Happy2	Young ---------- Elderly	97.6923 ---------- 96.6000	4.25929 ---------- 6.65227

Note: Sad1= Sentences conveying sad meanings presented without contextual information; Sad2= Sentences conveying sad meanings presented with contextual information; Happy1= Sentences conveying happy meanings presented without contextual information; Happy2=Sentences conveying happy meanings presented with contextual information.

Nonemotional Stimuli

No main effect or interaction was found for the data on the nonemotional stimuli. This outcome indicates that the elderly and the young adult groups performed comparably on the identification of both statements and questions.

Emotional Stimuli

A Group main effect was found for the data for the emotional stimuli [(1, 4) = 2.63, p = .048]. No other main effect or interaction was found. The finding of a Group main effect for this stimulus category indicates that the elderly and the young subject groups differed in their ability to recognize emotional meaning signaled by intonation in sentences presented with or without contextual information. ANOVA indicated that the elderly subjects performed comparably with the young adults on all measures except sad meanings in sentences presented in isolation (i.e., without contextual information). For this measure, the elderly subjects performed significantly below the level exhibited by the young adults (p = .008). The Group main effect is plotted in Figure 1.

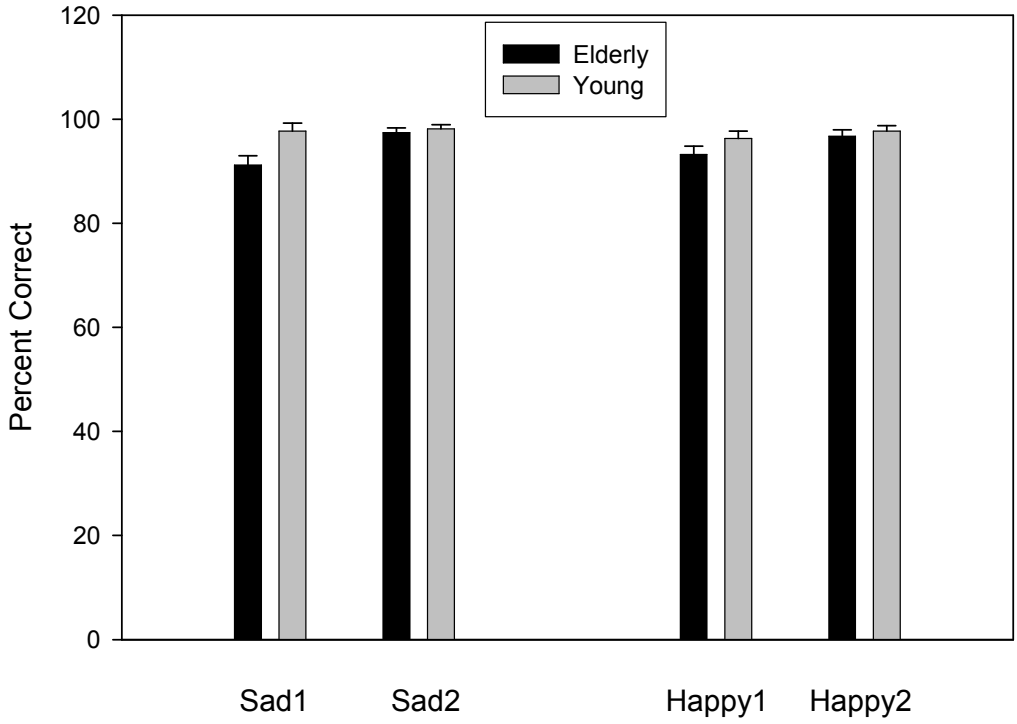

Figure 1: Identification of emotional meanings by Young vs. Elderly subjects. Sad1 stimuli are sentences conveying sad meanings that were presented without contextual information. Sad2 stimuli are sentences conveying sad meanings that were presented with contextual information. Happy1 stimuli are sentences conveying happy meanings that were presented without contextual information. Happy2 stimuli are sentences conveying happy meanings that were presented with contextual information.

CHAPTER V

DISCUSSION

Regardless of whether they passed or failed the hearing screening, the elderly subjects performed comparably with the young adults on various measures in the two stimulus categories (nonemotional and emotional). The only exception to this generalization has to do with the recognition of sad meanings presented in isolation (i.e., without contextual information). On this measure, the elderly subjects performed significantly below the outcomes for the young adults.

Similar to these results, various studies show that elderly adults generally have difficulty with perception of emotional meaning regardless of whether the stimulus is verbal (Brosgole & Weisman, 1995; Mitchell, Kingston & Barbosa Bouças, 2011; Ryan, Murray & Ruffman, 2010) or nonverbal (Mill, Allik, Realo & Valk, 2009; Philips, MacLean & Allen, 2002; Ruffman, Halberstadt & Murray, 2009). The manifestation of the problem across linguistic and nonlinguistic domains suggests that these individuals might have primary emotional processing deficit. However, whether this deficit alone accounts for the failure of the elderly subjects in the current study to recognize sad meanings in isolation is debatable. It is important to note that the problem was exhibited on only one of four measures that involved emotional processing. If its basis lied exclusively in emotional processing deficit, these subjects would have performed poorly

across all four measures. Thus, while possible, involvement of underlying emotional processing deficit in the current results does not seem particularly compelling.

It may be that elderly adults are impaired in the ability to decode some selective affective meanings conveyed by intonation. Data suggest that the recognition of emotions conveyed by intonation depends in part on ability to process acoustic properties of the stimulus (See Schirmer & Kotz, 2006). Intonation conveying sad meanings is characterized in part by a decrease in mean fundamental frequency (F0), F0 range, mean energy and downward-directed F0 contours (Banse & Scherer, 1996). Thus, sad emotions signaled by intonation are more subtle and less pronounced relative to happy emotions signalled by intonation, which are characterized by increases in mean F0, F0 range and mean energy (Banse & Scherer, 1996). These acoustic features are perceived as higher average pitch, faster speaking rate, and greater loudness. Perhaps elderly adults have difficulty processing the acoustic features of stimuli conveying sad but not happy emotions. Previous studies also found that elderly subjects are able to identify some but not all emotions signaled by intonation (Ruffman, Halberstadt & Murray, 2009; Ryan, Murray & Ruffman, 2010). For example, Ryan et al. (2010) reported that their elderly subjects had difficulty perceiving sad and angry emotions conveyed by intonation but not happiness and surprise.

The possible involvement of difficulties related to the processing of acoustic information might explain why these subjects performed poorly when the stimuli were presented in isolation, but they had no problem when the same stimuli were presented with contextual information. Caudwell (2002) also reported that his subjects were less

accurate at identifying emotions signaled by intonation stimuli presented in isolation but their performance improved significantly when the stimuli were presented in context. Similarly, the elderly subjects evaluated by Pichora-Fuller (2008) reportedly relied on contextual information when they experienced difficulty listening in challenging environments. Perhaps elderly adults rely more on contextual compared to acoustic information to process emotional meanings conveyed by intonation.

The finding that all of the elderly adults in the present study performed similarly across different measures regardless of their hearing status suggests that the deficit underlying the difficulty exhibited by these subjects might be unrelated to hearing loss. Previous studies that excluded (e.g., Dupuis & Pichora-Fuller, 2010) or included (Mitchell, Kingston & Barbosa Bouças, 2011; Orbelo et al., 2005) elderly subjects with hearing loss lend support to this interpretation. The elderly subjects evaluated by Mitchell, Kingston and Barbosa Bouças (2011), for example, experienced problems with intonation perception in emotional context regardless of whether they had high or low hearing sensitivity. Dupuis and Pichora-Fuller (2010) also found that their elderly subjects with normal hearing ability had difficulty discriminating different emotions signaled by intonation, although they were able to repeat the stimuli.

While it is unlikely that age-related hearing loss accounts for the impaired ability of elderly adults to extract relevant acoustic information from the stimuli, the extent to which this possibility can be generalized is unclear. The limited scope of the present study and the inconsistency of the literature on this issue dictate that caution is exercised in interpreting this aspect of the results. Some studies suggest that perceptual difficulties

experienced by elderly subjects during language communication in general may be due to hearing loss (Murphy et al., 2006 ; Schneider et al., 2000; Schneider et al., 2002). Similar to the outcomes of the present study, other reports indicate that the problem for these subjects might be independent of the effect of hearing loss (e.g., Mitchell 2007; Orbello, Grim, Talbott, & Ross, 2005).

One weakness of the literature has to do with criteria for subject recruitment. Information on hearing threshold for subjects is not always provided (e.g., Ryan, Murray, & Ruffman, 2010; Taler, Baum & Saumier, 2006). Although subjects in the present study were screened for hearing, threshold measures were not conducted. Data suggests that severe hearing loss might affect the ability to detect intonational meanings. Grant (1987) found that young subjects 22-36 years with profound hearing loss had difficulty perceiving intonation and stress. It may be that the perception of emotional meanings signaled by intonation depends in part on degree of hearing loss.

The normal performance of the elderly subjects on most of the experimental tasks may be due to the simplicity of the stimuli. While some of the stimuli had adverbial phrases in their composition, most of them were made up of sentences with subject-verb-object (S-V-O) word order, which is a basic syntactic unit of English. Studies in which elderly adults experienced difficulty with intonation perception in both emotional and nonemotional contexts used stimuli such as passive sentences that were syntactically more complex than sentences with S-V-O word order (Mitchell & Kingston, 2011; Mitchell, Kingston & Barbosa Bouças, 2011). Perhaps this finding was influenced by syntactic complexity.

Also, only two emotions were investigated. Whether the identification of emotional meanings other than those investigated could be a problem for the elderly subjects is unclear.

APPENDICES

Appendix A

Stimuli

Emotional stimuli without context

Intended Emotion	Sentences
Happy	**The mail came in at 3:00 pm.**
Happy	**Wane went to work after lunch.**
Happy	**The governor is here.**
Happy	**John saw the list.**
Happy	**My wife was at the meeting**.
Happy	**My dad is in London.**
Happy	**Laura left the key.**
Happy	**She found a card in her bag.**
Happy	**Harley saw the list last week.**
Happy	**Daniel has the book now.**

Happy	**The envelope is on the table**.
Happy	**Sally wrote down the address.**
Happy	**Sam opened the box.**
Happy	**The nurse walked up to John.**
Happy	**Andrea read the book**.
Happy	**The teacher gave out the exams.**
Happy	**Daniel saw the movie.**
Happy	**He got a new computer.**
Happy	**Lori went in after I left.**
Happy	**Laura was in London.**
Happy	**Mom was at the soccer game.**
Happy	**I had a call from the school.**
Happy	**The bouquet is red.**
Happy	**The bus arrives at noon.**
Happy	**Emma saw the crowd.**
Sad	**Sarah stopped by after**

	work.
Sad	**Aubrey saw the house last night.**
Sad	**Sally is in the room.**
Sad	**Mom had two jobs.**
Sad	**My parents lived in Europe.**
Sad	**John was in his uniform.**
Sad	**The lady saw her children.**
Sad	**Ben was in town last week.**
Sad	**There is a cat in the room.**
Sad	**Stephanie called the man on the phone.**
Sad	**The man is three years older.**
Sad	**Amy was at home.**
Sad	**Kevin signed the document.**
Sad	**The lady left the room.**
Sad	**Tyler walks to school.**

Sad	**Mark saw his stereo.**
Sad	**Leslie called her dad.**
Sad	**Michael ate all the crackers.**
Sad	**Judy baked the cookies.**
Sad	**Heidi stood behind the pews.**
Sad	**Matt narrated the story.**
Sad	**The light was off.**
Sad	**I saw the CD on my bed.**
Sad	**Grandpa sat on the chair.**
Sad	**The girl saw her doll.**

Emotional stimuli with contextual information

Happy	**The mail came in at 3:00 pm.** Mary received her letter before the deadline.
Happy	**Wane went to work after lunch.** He felt better after eating the food.
Happy	**The governor is here.** He will do something about the water problem
Happy	**John saw the list.** His son was one of the winners.
Happy	**My wife was at the meeting**. They agreed to rebuild the stadium.
Happy	**My dad is in London.** He will stay for my sister's wedding**.**
Happy	**Laura left the key.** We can stay in here as long as we want.
Happy	**She found a card in her bag.** It was my lost credit card.
Happy	**Harley saw the list last week.** She had won a vacation to Hawaii.
Happy	**Daniel has the book now.** He will do well on the test.
Happy	**The envelope is on the table**. It contains a gift from my sister.
Happy	**Sally wrote down the address.** She will visit her daughter soon.
Happy	**Sam opened the box.** He had a cat for his birthday.
Happy	**The nurse walked up to John.** She could not wait to announce the birth of his son.

Happy	**Andrea read the book**. It was about her son's life.
Happy	**The teacher gave out the exams.** Andrea had a 100%.
Happy	**Daniel saw the movie.** His son played the lead role.
Happy	**He got a new computer.** He was glad to get rid of his old one.
Happy	**Lori went in after I left.** She was happy to talk to her boss.
Happy	**Laura was in London.** She went to visit her family.
Happy	**Mom was at the soccer game.** My brother made the team.
Happy	**I had a call from the school.** The school wanted to inform me of my admission.
Happy	**The bouquet is red.** It will match the grooms tie.
Happy	**The bus arrives at noon.** I can have lunch before I leave for school.
Happy	**Emma saw the crowd.** She was excited about performing the song.
Sad	**Sarah stopped by after work.** She came to tell us that she was moving.
Sad	**Aubrey saw the house last night.** It was flooded to the roof.
Sad	**Sally is in the room.** Her leg is still sore.
Sad	**Mom had two jobs.** She never had time to rest.

Sad	**My parents lived in Europe.** We could not visit them because we lived far away.
Sad	**John was in his uniform.** He was not dressed up for the party.
Sad	**The lady saw her children.** They were covered with mud.
Sad	**Ben was in town last week.** He came for his dad's funeral.
Sad	**There is a cat in the room.** George can't come in because he hates cats.
Sad	**Stephanie called the man on the phone.** The police refused to let him talk.
Sad	**The man is three years older.** He will not be allowed to compete in the race.
Sad	**Amy was at home.** She could not make it to my graduation.
Sad	**Kevin signed the document.** He was buying a house for the first time.
Sad	**The lady left the room.** She was embarrassed to see her daughter.

Sad	**Tyler walks to school.** His car has still not been fixed.
Sad	**Mark saw his stereo.** It was broken beyond repair.
Sad	**Leslie called her dad.** She informed him of her mom's death.
Sad	**Michael ate all the crackers.** He had not eaten anything in days
Sad	**Judy baked the cookies.** She did not have enough for everyone.
Sad	**Heidi stood behind the pews.** There wasn't enough room to sit.
Sad	**Matt narrated the story.** Nobody believed that he was kidnapped.
Sad	**The light was off.** The boys were planning a surprise for dad.
Sad	**I saw the CD on my bed.** Abigail had been looking for it for days.
Sad	**Grandpa sat on the chair.** He forgot that it was wet.
Sad	**The girl saw her doll.** It was at the bottom of the river.

Nonemotional Stimuli	
Question	He lost the money?
Question	It was her ex-husband?
Question	It was not working?
Question	They got married in January?
Question	She was not ready to apologize?
Question	He admitted the crime?
Question	She was trying to save Eric?
Question	He would not even apologize?
Question	Henry is the love of her life?
Question	It was for me?
Question	Mark lied about it?
Question	She did not visit him?
Question	He organized a party for his friends?
Question	The book is with me?
Question	John gave you the key?
Question	Mum wants a cup of coffee?
Question	Sally comes from Seattle?

Question	The bag is blue?
Question	She saw the dress?
Question	Sheryl is in my house?
Question	The teacher was in the library?
Question	Maggie is in town?
Question	Sam comes here every year?
Question	You have been in bed all day?
Question	He will visit his family soon?
Statement	He lost the money.
Statement	It was her ex-husband.
Statement	It was not working.
Statement	They got married in January.
Statement	She was not ready to apologize.
Statement	He admitted the crime.
Statement	She was trying to save Eric.
Statement	He would not even apologize.
Statement	Henry is the love of her life.
Statement	It was for me.

Statement	Mark lied about it.
Statement	She did not visit him.
Statement	He organized a party for his friends.
Statement	The book is with me.
Statement	John gave you the key.
Statement	Mum wants a cup of coffee.
Statement	Sally comes from Seattle.
Statement	The bag is blue.
Statement	She saw the dress.
Statement	Sheryl is in my house.
Statement	The teacher was in the library.
Statement	Maggie is in town.
	Sam comes here every year.
Statement	You have been in bed all day.
Statement	He will visit his family soon.

References

Allen, R., & Brosgole, L. (1993). Facial and auditory affect recognition in senile geriatrics, the normal elderly and young adults. *International Journal of Neuroscience*, *68*, 33-42.

Banse, R., & Scherer, K.R. (1996). Acoustic profiles in vocal emotion expression. *Journal of Personality and Social Psychology*, *70*, 614-636.

Barrett, L. F., Lindquist, K., & Gendron, M. (2007). Language as a context for emotion perception. *Trends in Cognitive Science*, *11*, 327–332.

Bransford, J. D., & Johnson, M. K. (1972). Contextual prerequisites for understanding: Some investigations of comprehension and recall. *Journal of Verbal Learning and Verbal Behavior*, *11*, 717-726.

Brosgole, L., & Weisman, J., (1995). Mood recognition across the ages. *International Journal of Neuroscience*, *82*, 169–189.

Calder, A. J., Keane, J., Manly, T., Sprengelmeyer, R., Scott, S., Nimmo-Smith, I., & Young, A.W. (2003). Facial expression recognition across the adult life span. *Neuropsychologia*, *41*, 195-202.

Caudwell, R.T. (2000, September). *Where did the anger go? The role of context in interpreting emotion in speech*. Paper presented at the ISCA Workshop on Speech and Emotion: A Conceptual Framework for Research, Newcastle, Northern Ireland.

Cutler, A. (1977). The context dependence of intonational meanings. *Papers from the 13th Regional Meeting* (pp. 104–115). Chicago, IL: Chicago Linguistic Society.

Cutler, A., Dahan, D., & Van Donselaar, W. (1997). Prosody in the comprehension of spoken language: A literature review. *Language and Speech*, *40*, 141–201.

Crystal, D. (1975). *The English tone of voice*. London: Edward Arnold.

DeCasper, A. J., & Fifer W. P. (1980). Of Human Bonding: Newborns prefer their mother's voice. *Science*, *208* (4448), 1174-1176.

Delack, J. B., & Fowlow, P. J. (1987). The ontogenesis of differential vocalization: development of prosodic contrastivity during the first year of life. In N. Waterson, C. Snow (Eds.), *The development of communication* (pp. 93-110). New York: Wiley.

Dupuis, K., & Pichora-Fuller, M. K. (2010). Use of affective prosody by young and older adults. *Psychology and Aging, 25*(1), 16-29.

D'Esposito, M. (1999). Cognitive aging: new answers to old questions. *Current Biology, 9*, R939– R941.

Dore, J. (1975). Holophrases, speech acts and language universals. *Journal of Child Language. 2*(1), 21-40.

D'Odorico, L. (1984). Non-segmental features of prelinguistic communication: an analysis of some types of infant cry and non-cry vocalizations. *Journal of Child Language, 11*, 17–27.

Fransen, E., Lemkens, N., Van Laer, L., & Van Camp, G. (2003). Age-related hearing impairment (ARHI): environmental risk factors and genetic prospects. *Experimental Gerontology, 38*, 353–359.

Glucksberg, S., Kreuz, R. J., & Rho, S. H. (1986). Context can constrain lexical access: Implications for models of language comprehension. *Journal of Experimental Psychology: Learning Memory, and Cognition, 12*, 323-335.

Grady, C. L. (2000). Functional brain imaging and age-related changes in cognition. *Biological Psychology*, *54*, 259–281.

Grant, K. W. (1987). Identification of intonation contours by normally hearing and profoundly hearing impaired listeners. *Journal of the Acoustical Society of America*, 82, 1172–1178.

Kent, R. D., & Bauer, H. R. (1985). Vocalizations of one-year-olds. *Journal of Child Language, 12*, 491-526.

Kiss, I., & Ennis, T. (2001). Age-related decline in perception of prosodic affect. *Applications in Neuropsychology, 8,* 251–254.

Kramer, E. (1963). Judgment of personal characteristics and emotions from non-verbal properties of speech. *Psychological Bulletin*, *60,* 408-420.

Ladd, D. R. (1996). *Intonational phonology*. Cambridge, M.A: Cambridge University Press.

Lenneberg, E. H. (1967). *Biological foundations of language*. New York: Wiley.

Lehiste, I. (1970). *Suprasegmentals*. Cambridge, M.A: Cambridge University Press.

Loeb, D. F., & Allen, G. D. (1993). Preschoolers' imitation of intonation contours. *Journal of Speech, Language and Hearing Research*, *36*, 4–13.

Marcos, H. (1987). Communicative functions of pitch range and pitch direction in infants. *Journal of Child Language*, *14*, 255 – 268.

Mehler, J., Jusczyk, P., Lambertz, G., Halsted, N., Bertoncini, J., & Amiel-Tiso, C. (1988). A precursor of language acquisition in young infants. *Cognition, 29*, 143–178.

Mill, A., Allik J., Realo, A., & Valk, R. (2009). Age-related differences in emotion recognition ability: A Cross-Sectional Study. *Emotion, 9*(5), 619-630.

Mitchell, R. L. (2007). Age-related decline in the ability to decode emotional prosody: Primary or secondary phenomenon? *Cognition and Emotion, 7*, 1435–1454.

Mitchell, R. L., Kingston, R. A., & Barbosa Bouças, S. L. (2011). The specificity of age-related decline in interpretation of emotion cues from prosody. *Psychology and Aging, 26*(2), 406–414.

Mitchell, R. L., & Kingston, R. A. (2011). Is age-related decline in vocal emotion identification an artefact of labelling cognitions? *International Journal of Psychological Studies, 3*(2), 156–163.

Morton, J. B., & Trehub, S. E. (2001). Children's understanding of emotion in speech. *Child Development, 72,* 834–843.

Murphy, D. R., Daneman, M., & Schneider, B. A. (2006). Why do older adults have difficulty following conversations? *Psychology and Aging*, *21*, 49–61.

Nazzi, T., Floccia, C., & Bertoncini, J. (1998). Discrimination of pitch contours by neonates. *Infant Behavior and Development*, *21* (4), 779-784.

Orbelo, D. M., Grim, M. A., Talbott, R. E., & Ross, E. D. (2005). Impaired comprehension of affective prosody in elderly subjects is not predicted by age-related hearing loss or age-related cognitive deficits. *Journal of Geriatric Psychiatry and Neurology*, *18*, 25-32.

Paulmann, S., Pell, M. D., & Kotz, S. A. (2008). How aging affects the recognition of emotional speech. *Brain and Language*, *104*, 262–269.

Phillips, L. H., MacLean, R. D. J., & Allen, R. (2002). Age and the understanding of emotions: neuropsychological and sociocognitive perspectives. *Journals of Gerontology: Psychological Sciences, 57*, 526–530.

Pichora-Fuller, M. K. (2008). Use of supportive context by younger and older adult listeners: Balancing bottom-up and top-down information processing. *International Journal of Audiology*, *47*(2), S144–S154.

Raithel, V., & Hielscher-Fastabend, M. (2004). Emotional and linguistic perception of prosody. *Folia Phoniatrica et Logopaedica*, *56*, 7–13.

Richter, D., Dietzel, C., & Kunzmann, U. (2010). Age differences in emotion recognition: The task matters. *Journal of Gerontology: Psychological Sciences*, *66*, 48–55.

Roalf D. R., Pruis T. A., Stevens A. A., & Janowsky J. S. (2011). More is less: Emotion induced prefrontal cortex activity habituates in aging. *Neurobiology of Aging, 32*, 1634-1650.

Rogers, P. L., Scherer, K. R. & Rosenthal, R. (1971) Content filtering human speech: A simple electronic system. *Behavioral Research Methods and Instrumentation*, *3*, 16–18.

Ruffman, T., Halberstadt, J. B., & Murray, J. (2009). Recognition of facial, auditory, and bodily emotions in older adults. *The Journals of Gerontology, Series B: Psychological and Social Sciences, 64,* 696–703.

Ruffman, T., Henry, J. D., Livingstone, V., & Phillips, L. H. (2008). A meta-analytic review of emotion recognition and aging: Implications for neuropsychological models of aging. *Neuroscience and Biobehavioral Reviews, 32,* 863–881.

Ryan, M., Murray, J., & Ruffman, T. (2010). Aging and the perception of emotion: Processing vocal expressions alone and with faces. *Experimental Aging Research, 36*, 1–22.

Scherer, K. R. (1986). Vocal affect expression: A review and a model for future research. *Psychological Bulletin*, *99*, 143–165.

Schirmer, A., & Kotz, S. A. (2006). Beyond the right hemisphere: brain mechanisms mediating vocal emotional processing. *Trends in Cognitive Science*, *10*, 24–30.

Schneider B. A., Daneman M., Murphy D. R., & Kwong-See S. (2000). Listening to discourse in distracting settings: the effects of aging. *Psychology of Aging*, *15*(1), 110–125.

Schneider, B. A., Daneman, M. & Pichora-Fuller, M. K. (2002). Listening in aging: From discourse comprehension to psychoacoustics. *Canadian Journal of Experimental Psychology, 56*, 139-152.

Snow, D. (2006). Regression and reorganization of intonation between 6 and 23 months. *Child Development, 77* (2), 281-296.

Snow, D., & Balog, H. L. (2002). Do children produce the melody before the words? A review of developmental intonation research. *Lingua*, *112*, 1025–1058.

Taler, V., Baum, S., & Saumier, D. (2006). Perception of linguistic and affective prosody in younger and older adults. In R. Sun (Ed.), *Proceedings of the 28th Annual Conference of the Cognitive Science Society, Canada* (pp. 2216-2221).

Tessitore, A., Hariri, A. R., Fera, F., Smith, W. G., Das, S., Weinberger, D. R., & Mattay, V. S. (2005). Functional changes in the activity of brain regions underlying emotion processing in the elderly. *Psychiatry Research: Neuroimaging*, *139*, 9–18.

Tonks, J., Williams, W. H., Frampton, I., Yates, P., & Slater, A. (2007). Assessing emotion recognition in 9–15-years olds: Preliminary analysis of abilities in reading emotion from faces, voices and eyes. *Brain Injury*, *21*, 623–629.

Walker, A. S., & Grolnick, W. (1983). Discrimination of vocal expressions by young infants. *Infant Behavior and Development, 6,* 491-498.