

Age effects on auditory sensory memory:
a cognitive neuroscience perspective

Rowena Jane Cooper

BA (Psychology) (Hons I)

This thesis is submitted for the degree of Doctor of Philosophy,
University of Newcastle, Australia

Submitted: February 2009

Statements by the candidate

Statement of originality

This thesis contains no material which has been accepted 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 in the text. I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying subject to the provisions of the Copyright Act 1968.

Declarations

I hereby certify that the work embodied in this thesis has been done in collaboration with other researchers. I have here included as part of the thesis a statement clearly outlining the extent of collaboration, with whom and under what auspices.

The second study presented in this thesis was completed in collaboration with two researchers, Ms Rosemary Clark and Ms Rebbekah Atkinson. Approximately one third of the participants tested for study 2 were tested by Ms Clark. Ms Clark submitted her honours thesis in psychology based on the data she collected from this subset of participants. Ms Atkinson was also responsible for testing approximately one third of participants for study 2 as a research assistant.

Candidates signature:

Date:

Acknowledgements

First and foremost, I would like to thank my primary supervisor, Professor Pat Michie, for her expert guidance and support. It has been a pleasure to have been supervised by such an inspiring woman. In addition, I would like to thank my co-supervisor, Dr. Juanita Todd, for her thought provoking comments and fresh perspectives. Juanita's passion for her work sparked my initial interest in aging and event-related potential research. Thanks also to Bill Budd for helpful comments on my work.

I am indebted to all the participants who offered their time to take part in this research. For their assistance in recruiting older adults, I would like to thank the Hunter Medical Research Institute and those running the research volunteer register, Debbie Quain and Trisha D'Accione. I wish to acknowledge the support of the School of Psychology and the Faculty of Science and IT for providing research funding throughout my studies. I was also supported by an Australian Postgraduate Award. For the technical support that I received during the course of my doctoral studies, I would like to thank David Paul, Damien Mannion, Gavin Cooper, Bryan Paton, David McKenzie, and Tony Kemp. I would also like to thank Rosemary Clark and Rebbekah Atkinson for their help in testing participants for my second study. The general staff in the school of psychology deserve special mention for their assistance with administrative aspects of my studies: Anne Quayle, Sharon Harris, Lynne Brunt, Jeff Drummond, Sandra Dimmock, and Kyle Holmes.

Thanks to the members of the Functional Neuroimaging Laboratory, especially those who helped me in the early days, Carmen, Rebecca, Amy, Natasha, Matt, and Sharna. To my office mates past and present, thank you for brightening up those long office days. A special thanks goes out to all my family and friends who helped me through the PhD highs and lows.

Dedication

Thank you to my dear husband, Rusty. I have saved my greatest cliché for you: I could not have done this without you (at least not with my sanity quite so intact). You believed in me throughout. You cooked me delicious dinners, listened to the dramas, remained calm, kept me laughing, and generally helped me through. For these reasons and many more, I would like to dedicate this work to you.

Table of contents

Abstract.....	8
Chapter 1: Introduction	11
Age effects on auditory sensory memory: a cognitive neuroscience perspective.....	12
A review of aging research and the cognitive neuroscience of aging.....	12
Theories regarding the relationship between sensory and cognitive functioning with age	14
Cognitive aging theories	18
Neuroimaging evidence: Mechanisms potentially mediating cognitive age-related change	21
Overview of sensory changes which occur with age in the auditory modality.....	24
Overview of memory systems and age-related changes in memory functioning	27
Auditory sensory memory and the role of the auditory cortex	37
The auditory event-related potential	42
P1 waveform	44
N1 and P2 waveforms	46
N2 waveform	49
Mismatch Negativity.....	50
Repetition Positivity.....	60
Summary of the relationship between auditory ERP waveforms and auditory sensory memory	65
The present studies.....	67
Chapter 2: study 1	72
Age-related changes in the auditory event-related potential: the effect of stimulus onset asynchrony	73
Method	79
Participants.....	79
Stimuli and procedure	81
EEG Recording	82
Data Analysis	82
Results.....	84
N1 peak amplitude	86
N1 peak amplitude at the mastoids	89
N1 peak latency.....	90
Ta and Tb mean amplitude	90
P2 peak amplitude.....	91
P2 peak amplitude at the mastoids.....	93
P2 latency.....	93
Correlations between hearing thresholds and N1 and P2 amplitude	95
Discussion	95
References.....	100
Chapter 3: study 2	105
The event-related potential reveals modeling of auditory repetition in the brain	106

Method	111
Participants.....	111
Stimuli and procedure	111
EEG Recording	112
Data Analysis	113
Results.....	114
The ERP to standards.....	114
The repetition positivity	117
The ERP to deviants.....	119
The mismatch negativity	120
Discussion	121
Conclusions	127
References.....	128
 Chapter 4: study 3	 130
Repetition effects on auditory sensory memory in young and older adults: an event-related potential study	131
Method	136
Participants.....	136
Stimuli and procedure	138
EEG Recording	140
Data Analysis	140
Results.....	142
Standards.....	142
Repetition positivity	146
Deviants	147
Mismatch Negativity.....	149
Neuropsychological test data and correlational analyses.....	151
Discussion	153
Conclusions	158
References.....	159
 Chapter 5: study 4	 162
In search of a behavioural correlate of repetition positivity in young and older adults.....	163
Method	168
Participants.....	168
Stimuli and procedure	170
EEG Recording	173
Data Analysis	174
Results.....	176
The ERP to standards in the passive condition	176
Repetition positivity in the passive condition	179
Correlations between RP and behavioural measures	182
Correlations between RP and auditory verbal memory measures	183
Discussion	186
The effect of repetition on the auditory ERP	186
Is there a behavioural correlate of RP?	188

The relationship between RP and auditory verbal memory	191
Potential caveats.....	192
Conclusions.....	194
References.....	195
Chapter 6	199
General Discussion	200
Summary of the research studies	200
Age-related change in auditory sensory memory and the auditory ERP	201
Hearing sensitivity of older adults across studies	201
A note on P1 and N2 waveforms	201
N1 and P2 waveforms	203
Repetition positivity.....	205
MMN and the MMN memory trace effect.....	209
The relationship between sensory and cognitive processing with age.....	209
The issue of compensatory brain activity	211
Theories of aging supported by the research	213
Conclusions and future directions.....	217
Appendix 1	222
Issues remaining with respect to RP	222
Amalgamated reference list	227

Abstract

It is well established that there are changes in cognition and in peripheral sensory mechanisms that occur with age. However, there is much less known about the cause of either change or indeed the relationship between age-related change in sensory processing and age-associated cognitive decline. Understanding these mechanisms could improve our capacity to devise strategies which could assist older adults in aging successfully. In this thesis, I aim to bridge a gap in our knowledge concerning the relationship between age-related change in sensory processing and age-associated cognitive decline by studying the effect of age on what can be considered an intermediary process, sensory memory (in the auditory modality). I continue this line of research by examining the relationship between auditory sensory memory and other types of memory for auditory information in young and older adults. To address these goals, I adopted a cognitive neuroscience approach, relating electrophysiological data to data derived from behavioural memory assessments.

In the following thesis, I present a literature review, four studies, and a general discussion of results. Several waveforms of the auditory event-related potential (ERP), including N1, P2, repetition positivity (RP), and mismatch negativity (MMN) were studied. More specifically, in study 1, we looked at the effect of age on N1 and P2 amplitude. In study 2, we examined the conditions eliciting two repetition effects, RP and the MMN memory trace effect, in the auditory ERP of young adults. Studies 3 and 4 concerned the effect of age on RP and the relationship between RP and implicit memory for contextual information as well as explicit memory for auditory information.

We concluded that i) age affects auditory sensory memory, ii) the potential relationship between auditory sensory memory and implicit memory for auditory information requires re-investigation, and iii) there is a relationship between auditory

sensory memory and explicit memory for auditory information that is altered with age. That is, we concluded that RP occurring in the N1/P2 and MMN latency period indicates memory trace formation and that age affects RP amplitude (restricted to an anterior RP generator). In addition, we showed that RP may be related to implicit memory (priming) in both young and older adults. Across two studies, we found a positive correlation between the response to repetition in the ERP (due to RP activity) and explicit auditory verbal memory in young adults but a negative correlation in older adults.

Therefore, although age-related change in RP could reflect the capacity of older adults to encode the context of auditory stimulation, this is potentially due to compensatory activity. We argue it is possible that implicit memory changes with age as a result of age-related change in explicit episodic memory. As a result of well established changes that occur in episodic memory with age, older adults may begin to rely on implicit memory as a source of memory more so than young adults. Our data shows that the implicit memory system may, as a result, favour content over contextual information. An important theme outlined in the discussion of results involves the idea that age-related changes in cognition that are commonly interpreted as cognitive deficits may in fact be beneficial in certain circumstances.

We review our results in relation to cognitive theories of aging and find that several theories are applicable to the data, including the frontal hypothesis (incorporating the inhibitory deficit hypothesis), the information degradation hypothesis, and the speed of processing hypothesis. Future research in this area could focus on exploring whether top-down or bottom-up or influences primarily contribute to the age effect on auditory sensory memory and RP, as well as evaluating our hypothesis that the age-related change in RP may be beneficial for explicit item memory but detrimental for implicit contextual memory

in older adults (i.e. compensatory mechanisms). While the studies presented in this thesis have provided the foundations guiding our understanding of these issues, researchers in the field of cognitive neuroscience are well equipped to resolve such questions in the future.