B.Sc. (Hons) Psychology

Final Year Project

Impact of Tinnitus on cognitive ability: Irrelevant sound effect and music

2018

Dissertation submitted in partial fulfilment of the requirements of Cardiff Metropolitan University for the degree of Bachelor of Science
DECLARATION

I hereby declare that this dissertation is the result of my own independent investigation under the supervision of my tutor. The various sources to which I am indebted are clearly indicated. This dissertation has not been accepted in substance for any other degree, and is not being submitted concurrently for any other degree.

[Signature]
Candidate
ACKNOWLEDGEMENTS

Firstly, I would like to thank all the tutors who have helped me throughout this degree especially for putting up with me.

A big thank you to for his calm support during this project, enthusiasm and sharing his great knowledge.

A very special thanks to my family for their patience and support during this degree but especially this last year. and Mum, I couldn’t have continued or finished without you.

Thank you to all my friends for your support, it means the world to me.

And finally, to those friends I have made during my educational journey, you made it worthwhile.
Abstract

The ability to perform serial recall tasks is impaired when irrelevant speech or sound is present is known as the Irrelevant Sound Effect (ISE). There is much evidence to show that a variety of sounds can cause ISE including; steady state sounds such as pure tones, changing state sounds which have a variable quality, such as music (with or without lyrics). It would appear, that people who experience tinnitus also hear a variety of sounds internally in the absence of external stimulus, that may be classed as steady or changing state in quality. Within the literature for ISE, the control condition is a quiet state where no external sound is experienced, all other measures of ISE are taken against this score. It is possible that tinnitus may interfere with recall ability in both a negative and positive way, depending on the sound condition. In this study, two groups (11 participants) were compared, one with non-tinnitus (control) and one without tinnitus. They followed a normal ISE paradigm using quiet, steady, liked music and disliked music as the sound conditions whilst recalling 9 digits (1-9). A subjective scale was used to measure feelings relating to actual score and qualities of each condition. The results indicated that the tinnitus group performed better than the non-tinnitus group in the quiet and steady state conditions and then followed normal ISE patterns in their scores, the control group did not follow regular ISE patterns as their results showed that they performed best in both the music conditions. No significant interaction was found between groups. These results do not follow the tinnitus literature relating to reduced cognitive ability or the ISE literature for the control group, therefore future research may be warranted to gain further understanding.
## Table of contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Declaration</td>
<td>i</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>ii</td>
</tr>
<tr>
<td>Abstract</td>
<td>iii</td>
</tr>
<tr>
<td>Table of contents</td>
<td>iv</td>
</tr>
<tr>
<td>Figures</td>
<td>v</td>
</tr>
<tr>
<td>1 Introduction</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Rational/ hypothesis</td>
<td>5</td>
</tr>
<tr>
<td>2 Methodology</td>
<td>6</td>
</tr>
<tr>
<td>2.1 Participants</td>
<td>6</td>
</tr>
<tr>
<td>2.2 Design</td>
<td>6</td>
</tr>
<tr>
<td>2.3 Materials</td>
<td>6</td>
</tr>
<tr>
<td>2.4 Procedure</td>
<td>7</td>
</tr>
<tr>
<td>3 Results</td>
<td>8</td>
</tr>
<tr>
<td>4 Discussion</td>
<td>11</td>
</tr>
<tr>
<td>4.1 Limitations and further study</td>
<td>14</td>
</tr>
<tr>
<td>4.2 Conclusion</td>
<td>15</td>
</tr>
<tr>
<td>5 References</td>
<td>16</td>
</tr>
<tr>
<td>6 Word count declaration</td>
<td>19</td>
</tr>
</tbody>
</table>
# List of figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Mean scores for ISE serial recall test</td>
<td>8</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Subjective score ratings</td>
<td>9</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Subjective likeable ratings</td>
<td>9</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Subjective pleasantness ratings</td>
<td>9</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Subjective offensiveness ratings</td>
<td>10</td>
</tr>
</tbody>
</table>
1. Introduction

The detrimental effect of speech and sound when engaged in tasks that require the use of short term memory is well documented (Jones & Macken, 1993; Salame & Baddeley, 1989; Tolan, 2002). These acoustic distractions cause the phenomena known as Irrelevant Sound effect (ISE) and have been shown to cause issues in many cognitive tasks and situations where external stimulus is present, such as open offices (Brocolini, Parizet & Chevret, 2016; Yadav, Kim, Cabera & de Dear, 2017). In order to assess this phenomenon, serial recall tasks are combined with a range of sound conditions to see the effect on cognition and short-term memory. Serial recall tasks require the participant to watch a visual presentation of 8 – 12 numbers, remember them and write down at the end of the set (Viswananthan, Dorsi & George, 2014). During these tasks, the participant may or may not experience audible distractions. In order to gain further insights into ISE, both variables of visual and audio stimulus can be manipulated. The main changes are to audio stimulus/ sound conditions (Perham & Currie, 2014; Viswananthan, et al., 2014). In quiet conditions the task is carried out in silence, in steady state the sound remains the same and does not change tone or rhythm, a typical sound would be a single repeated letter and lastly the changing state sound can be any sound that has acoustical variation such as speech or music that may or may not include lyrics (Campbell, Beaman & Berry, 2002; Marsh, Hughes & Jones, 2009; Perham & Currie, 2014) There is very strong evidence to show that the quiet condition, where no sound is experienced during the recall task allows for the best concentration and cognitive ability (Jones, Aubin & Trembley, 1999; LeCompte, 1996; Perham & Currie, 2014).

The quiet sound condition is generally used as the control against which all other sound conditions are compared to gauge the level of distraction from the other conditions. In the quiet sound conditions, participants are devoid of any external audio stimulus but what appears to be unacknowledged in ISE studies is that for up to 40% of the population, they may be experiencing internal sounds known as tinnitus which can be heard when the surrounding environment is quiet (Hesse, 2016 Sandlin & Olsson, 1999; Trevis, McLachlan & Wilson, 2016). This internal sound maybe creating sound conditions internally that are in conflict/ interfere with the needs of ISE studies and potentially undermining research. There is a small amount
of research into working memory/ cognitive tasks and tinnitus which has shown that there is a negative effect of tinnitus on performance due to interference, although more research is linked to self-reported reduced performance (Mohamad, Hoare & Hall, 2016; Trevis, et al., 2016; Stevens, Walker, Boyer & Gallagher, 2007).

Self-report questionnaires completed by tinnitus outpatients showed a belief that their ability to concentrate on a task is impaired, this was supported by the results of reduced reaction times across five cognitive tasks when compared to people without tinnitus (Hallam, McKenna & Shurlock, 2004). Trevis, et al. (2016) found that their tinnitus group revealed significantly slower responses to the cognitive task when completed in silence, compared with their healthy control group. A different study which looked at chronic, severe tinnitus concluded that when the participant was engaged in a Stoop task or dual task (word reading and reaction time task performed simultaneously), reaction times were impaired when compared to the control group (Stevens, et al., 2007). Thus, it would seem prudent to investigate whether there is an impact of tinnitus on cognition in ISE studies.

There are two types of tinnitus, the first ‘objective’ tinnitus which is less frequent, relates to noises heard that emanate from inside the body itself which are often described as whooshing or clicking sounds that are linked to the internal workings of the body, such as blood flow and muscle contractions (Hesse, 2016; Sandlin & Olsson, 1999). The second type is much more common, which is ‘subjective’ tinnitus, is a condition where in the absence of external sound/stimulus, the brain creates and ‘hears’ sound as if it they were external (Eggermont & Tass, 2015; Weidt, et al., 2016). These sounds are many varied and described as; hissing, ringing, pure tones and can occur in multiples at the same time (Eggermont & Tass, 2015; Lockwood, et al., 2002). Tinnitus may be unilateral or bilateral, it can be constant or intermittent, the tone and frequency may also vary considerably for an individual and between individuals (Lockwood, et al., 2002). For many people, they may not even be aware that the noises they experience are an actual condition, mistakenly believing that it is just an idiosyncrasy that no one else experiences.

The aetiology of tinnitus is very unclear, for some it may be caused by head injury or illness but for the vast majority, evidence appears to point to excessive or prolonged noise exposure and hearing loss (Eggermont & Tass, 2015; Hesse, 2016; Lockwood, et al., 2002). Recurrent ear infections may cause internal damage to the tiny hairs in the ear, thus causing tinnitus.
Hearing loss appears to have strong correlates with tone and pitch of tinnitus being linked strongly to the tones and pitches lost in the individuals hearing, it is thought that the brain is trying to recreate the sound that has been lost (Lockwood, et al., 2002). The effects of tinnitus are wide ranging, mainly classed as subjective, with some people barely noticing the sound through to others who experience severe depression, anxiety and some may even contemplate suicide due to the severity (Trevis, et al., 2016; Weidt et al., 2016).

It is suggested that tinnitus can become very challenging to reduce due to the emotional cycle of depression and anxiety which both interact to continue or increase the tinnitus, which in turn interacts with the depression and anxiety (Trevis, et al., 2016). Due to this negative emotional cycle, some therapies such as cognitive behavioural therapy or talking therapies are offered as they have shown some potential with improving quality of life, although it does not actually reduce tinnitus, the ability to cope with life better may reduce the effects of tinnitus on the individual (Hesse, 2016). Tinnitus is recorded as interfering with peoples’ ability to concentrate or follow conversations, drawing attention away from relevant sound and redirecting towards the tinnitus, effectively acting as an irrelevant sound (Mohamad et al, 2016).

The sound conditions within ISE studies can be linked to those sounds heard by people with tinnitus. Steady state sounds in ISE studies may be white, pink or tonal noises, these could be described as similar to the sounds reported by some people with tinnitus; low pitched buzzing, high pitch whistling or hissing (Eggermont & Tass, 2015; Jones & Macken, 1993; Hesse, 2016; Marsh, et al., 2009; Perham & Banbury, 2011; Viswanathan, et al., 2014). The ability to mask irrelevant sound using steady state sounds such as white/pink noise or sound that is monotonous such a repeated ‘G’ sound has shown promise due to its ability to reduce the natural fluctuation/ melody that occurs in speech conditions, when compared to changing state conditions (Jones & Macken, 1993; Perham & Banbury, 2011). For many people with tinnitus, they may hear these sounds that could be regarded as steady state which, in turn have the potential to act as a masking sound during ISE studies. As mentioned above, tinnitus may be heard unilaterally or bilaterally with only one sound heard or multiple sounds which can vary in intensity and loudness (Lockwood, et al., 2002; Sandlin & Olsson, 1999). Studies in ISE have reported detrimental effects when four tones are presented instead of one and when...
sound is presented to left ear only compared with the right ear but, both were significantly worse than the quiet condition (Jones, et al., 1999; Hadlington, Bridges & Darby, 2004). This leaves a question about how tinnitus may affect the outcomes of ISE studies, should screening take place to acknowledge tinnitus before studies take place and will they affect outcomes in studies?

Tinnitus cannot be cured as yet, but there is growing clinical interest in supportive therapies and researching new theoretical approaches (Hesse, 2016; Trevis, et al., 2016). The majority of people with tinnitus do not seek medical support (Lockwood, et al., 2002). The general advice given to people with tinnitus is to avoid quiet situations; to engage in ‘sound therapy’ using self-help techniques such as increasing environmental sounds by opening windows, keeping the radio/ music on at a comfortable level or using smartphone apps (British Tinnitus Association, 2018). Clinical therapies include; music, retraining and habituation therapies which aim to redirect the focus of attention away from the tinnitus towards the intended sound, thus filtering the sound and hopefully using the brains plasticity to extinguish its previous links although, Hesse (2016) believes that scientific proof of improvement is limited due to a lack of good/ correct data, long term effects not being evaluated and very small sample sizes leading to limited result powers (Fukuda, Miyashita, Inamoto & Mori, 2011; Hesse, 2016). Often, other therapies are involved such as counselling and education so that individuals can take back control of what is believed to be an emotional link tied into the tinnitus (Hesse, 2016). Therefore, studies have not been able to form a causal link to sound/ music within those therapies (Hesse, 2016).

Al-Jassim (1988) carried out a study where a tinnitus group were able to try a couple of different sound methods on tape to mask their tinnitus and improve life quality. The first sound tape consisted of a variety of pure tones, the second was narrow and wide band noise, the third was relaxing music and the forth was general music (Al-Jassim, 1988). Out of the forty-one patients in the group, thirty-six choose music as their preferred masker, this suggests that music may be useful when there is a need to concentrate and remove the interruption of tinnitus (Al-Jassim, 1988). ISE studies have also used music both lyrical and instrumental to observe the interaction with background sound, with all music conditions producing negative performance compared to quiet conditions (Perham & Currie, 2014; Perham & Sykora, 2012; Salame & Baddeley, 1989; Soh & Lim, 2013). Music that has the right
tempo, which is linked to mode, has been shown to increase the ability to concentrate and complete tasks; the suggestion is that internal arousal increases which in turn, increases mood (Husain, Thompson & Schellenberg, 2002).

People with tinnitus believe that they are affected by lack of concentration and a reduced ability to complete cognitive tasks well, as mentioned above. Perham and Sykora (2012) used a ratings scale to allow ISE study participants to rate how well they thought they performed during the study and to rate various properties in each sound condition. The objective scores showed that, in line with pervious ISE studies, quiet was the best condition but interestingly, disliked was a better condition than liked music (Perham & Sykora, 2012). The subjective ratings showed that participants thought that the quiet condition would be the best condition but believed that they would be negatively affected by both the liked and disliked equally; the subjective rating of distracting may be linked to this (Perham & Sykora, 2012). This is another area where the effect of tinnitus on ISE studies is unknown but also, it would be a good opportunity to examine whether performance is affected by music for people with tinnitus. It would also be interesting to compare objective and subjective findings for people with tinnitus and without regarding sound conditions and their performance.

1.2, Rational/ hypothesis

Therefore, this study will use an ISE paradigm and subjective ratings scale in order to investigate whether a tinnitus group compared with a non-tinnitus control group shows differences in scores, both objective and subjective. Both groups will partake in four sound conditions; quiet state, steady state, liked music and disliked music. In the first instance, it is hypothesised that in the quiet condition, the tinnitus group will report negative affects both objectively and subjectively due to the interference caused by their tinnitus. The second hypothesis posed, is that in the steady state condition, the tinnitus group will improve their score compared to the quiet condition and that the control group will deteriorate compared to their quiet state score. This may be due the masking effect of their own tinnitus by the steady state condition. The third hypothesis is that the tinnitus group will show similar performance in the liked music compared with the steady state and that subjective scores will show a belief of increased ability in the liked music state.
It is hoped that the findings may also suggest ways that ISE studies could be integrated into future studies with tinnitus and cognitive tasks. Also, if there is an impact of tinnitus on the results, this may require discussion in the ISE research community.

2. Method

2.1. Participants

Participants were gathered via snowballing for both tinnitus and non-tinnitus participants. 2 groups were formed, the first group of with tinnitus and the second without. Mean age of group 1 is 45.4 years old (2 male, 3 female); mean age of group 2 is 31.5 years old (4 male, 2 female).

2.2. Design

The design is a two-way, repeated measure ANOVA. 2 independent variables of between group (tinnitus and non-tinnitus) and the within variable of sound state (quiet, steady, liked and disliked). 1 dependent variable of test score. The ANOVA was also completed for the subjective ratings questionnaire scores.

2.3. Materials

The visual section of the recall task was created with Word 2010 power point. The screen is a white background with the numbers 1 - 9 placed in the centre, font size 60, font style Calibre (body) and coloured black. A total of 60 sets of 9 numbers, randomly sequenced will be shown with 15 sets per sound condition. During the set the numbers appear on screen for 700msec and are replaced by a blank screen for 300msec. At the end of each set, participants were visually instructed by a ‘recall’ screen, to write down their recall of the set onto their answer sheet. The answer sheet was a table corresponding to each set and columns for all 9 numbers. After recall is completed, they moved onto the next set by pressing the space bar on the laptop. They see a blank screen before the set starts again. An Acer Aspire laptop will be used due to its portability.
The sound conditions were played through headphones (beats: by dr dre, Solo HD) to reduce any external interference and produce a reasonable sound level, the sound was set at 14 for both groups. The steady state is a recorded female voice repeating the letter G. The changing state lyrical content was obtained from Google Play Music due its wide choice and good sound quality. The participant will choose their own liked music choice. The disliked music is Death Angel’s “The Moth” as research shows the death metal genre to be one of the most disliked (Perham & Vizard, 2011).

The tinnitus group were asked to complete ‘The tinnitus handicap inventory’ and the first page of the ‘Tinnitus history’ to gain a snapshot of the tinnitus cohort and allow exploration into any difference within the group results if warranted.

2.4. Procedure

Participants were tested in quiet rooms to rule out distractions. They were informed of the confidentiality policy, their right to withdraw (themselves and/or their data) up until the data is collated and the procedures for the study, both verbally and in writing. They completed a consent form and started the study. The participant was also informed that they could take a break if needed. The participant chose their music which was loaded onto the computer along with the other sound conditions. All sound conditions were randomised so that each group and participant received a different order. The participant was told to ignore any sounds that come through the headphones as they were not part of the test. They were tested individually. A test run of 10 sets were completed in the quiet condition to allow the participants to get a feel for the test, results were not counted for this. Participants saw a visual cue on screen where they were instructed to press the spacebar on the laptop by the ‘press space bar to start’ slide, they then had to watch the screen, remember the 9 numbers in order and write them on the recall sheet when prompted by the ‘Recall now’ slide. This was repeated as necessary until they were instructed to ‘Please Contact Test Instructor Before Continuing’ to allow for changes of sound condition from quiet through to steady state, liked/disliked music and allow for a break for the participant if needed. At the end of the session, the non-tinnitus group were thanked for their time and allowed to leave. The tinnitus group were asked to complete two questionnaires related to their personal experiences, if they were happy to do so, and then thanked for their time (no extra personally identifiable information was included in the questionnaires).
3. Results

The raw data was deemed correct if the correct digit was in the correct recall position in line with previous studies serial recall criteria. All raw data was used. A mixed design ANOVA was used to analyse the data of the serial recall task. The between variable was group (tinnitus and non-tinnitus), within variable was sound condition (quiet, steady state, liked and disliked) and the dependent variable was score.

Results showed that the assumption of sphericity has not been violated; Mauchly’s test results are $\chi^2(5) = 3.865, p = .572$ and Levene’s; disliked, $p=.122$, liked, $p=.094$, quiet, $p=.107$ and steady, $p=.107$. Within subjects there was a significant effect of sound conditions, $F(3, 27) = 5.29, MSE = .489, p=.005$, but not of groups, $F(1, 9) = .017, MSE = 14.14, p= .898$. Further planned post hoc analysis showed significant difference between quiet and disliked sound states ($p= .37$). This difference was shown in the tinnitus group ($p = .46$) but not in the non-tinnitus group. All other results were non-significant. Figure 1 shows the mean scores for the serial recall task. As can be seen, the non-tinnitus group performed equally in the disliked music and the steady state but achieved better recall in the liked and quiet states, again achieving very similar results. The tinnitus group were most affected by the disliked music and least affected by the quiet sound condition.

![Figure 1. Mean scores for serial recall task according to number of correct digits in correct position.](image-url)
We also asked the participants to fill out a questionnaire about how confident they were about their performance. They rated themselves between 1 – 100, with 1 being terrible and 100 being fantastic. Figure 2 shows the mean scores. A mixed ANOVA was completed which showed sphericity was violated, Mauchly’s test $\chi^2(5) = 11.299, p = .47$. Therefore, degrees of freedom have been corrected using Greenhouse-Geisser ($\epsilon = .533$). There was a main effect of subjective score, $F(1.598,27) = 6.559, \text{MSE} = 297.805, p = .013$. Score by group was not significant. As can be seen in figure 2, both groups thought they perform the well in the liked music sound state and quiet state with the worst being the disliked state.

![Figure 2. Subjective scores ratings related to each sound condition.](image)

![Figure 3. Subjective likeable ratings.](image)

![Figure 4, Subjective pleasant ratings.](image)
Figure 3 shows how ‘likeable’ each sound condition was for the participants. A mixed ANOVA showed the sphericity is not violated, Mauchly’s test $\chi^2(5) = 5.339, p = .379$. No effect was found for likeable by group. Post hoc tests showed a significant effect between disliked and liked music sound state ($p = .015$) and disliked music and quiet sound state ($p = .040$). As can be seen, both groups found the likeable music and quiet states to be the most likeable with the disliked music being the most disliked. Figure 4 shows how pleasant the participants found each state. Mauchly’s was not significant, $\chi^2(5) = 3.043, p = .695$, showing that sphericity was not violated. A main effect of pleasantness on sound state was found, $F(3,27) = 17.075, \text{MSE} = 612.284, p = < .001$. Post hoc tests showed a significant effect between disliked and liked ($p = .001$), disliked and quiet ($p = .032$).

Figure 5, (below) shows the subjective scores for how offensive each sound state was, scores were reversed with 1 being not at all offensive and 100 being completely offensive. Mauchly’s was significant $\chi^2(5) = 13.377, p = .021$, thus violating sphericity. Degrees of freedom have been corrected by using Huynh-Feldt ($\epsilon = 1$). Ratings of offensiveness had a main effect, $F(3,27) = 12.219, \text{MSE} = 860.463, p = < .001$. Post hoc tests showed significant effects with liked music ($p = .010$) and with quiet state ($p = .042$).

**Figure 5**, Graph showing reversed scored means for subjective score of offensiveness. 0 is defined as not at all offensive with 100 being completely offensive.
4. Discussion

This study used a typical ISE paradigm to compare results between two groups, one with tinnitus and one without (control). The results of this study gave a very mixed bag of results regarding the hypotheses. There was no support for hypothesis 1 of negative effects of tinnitus in the quiet condition as the both the objective and subjective scores were highest on the quiet sound condition. The second hypothesis was partially supported due to reduced recall score in the control group. But interestingly, although the score did not improve for the tinnitus group compared with the quiet condition, their score was still higher than the control group score for steady state. The third hypothesis was not fully supported as the tinnitus groups performance showed more errors than in the liked music condition compared with the steady state condition. In contrast, they did predict that their recall would be better in the liked music compared to the steady state. These results are discussed in more detail below.

It was surprising to find that the tinnitus group performed better in the quiet state compared to the control group. Current literature, albeit a small amount, shows reduced cognitive abilities and emotional regulation which gives the impression that the internal distraction of tinnitus could have affected their ability to complete the task (Trevis, et al., 2016). Del Bo, et al., (2008) reported that even people without tinnitus will hear sounds in the absence of audible sound being present. A group of 53 participants were tested in an empty sound proof room, the majority of participants ‘heard’ a sound such as a buzz or a hum, the number of people who can heard noise increased when in the presence of a device that can emit sound, such as speakers (Del Bo, et al., 2008). It is feasible to suggest that in this study, the control group may have been distracted by a small amount of internal noise which they are not used to whereas, the tinnitus group are used to/ habituated to their noise so are better equipped to focus with the internal noise (Lockwood, et al., 2002). It is possible that their subjective view of tinnitus is that it is loud and distracting but if it were to be measured, maybe quite quiet (Lockwood, et al., 2002). Within the subjective scores, the tinnitus group felt that they would recall the most numbers in the quiet state followed by liked music. This is a little surprising given that other studies linked to tinnitus show increased errors during cognitive tasks (Trevis, et al., 2016).
Again, the objective scores showed that the tinnitus group had better recall in the steady state conditions compared with the control group. Although the tinnitus group did not improve their recall score when compared to the quiet state, they did perform better than the control group. The performance for both groups showed higher error rates when compared to the quiet condition which is in line with ISE research. Tinnitus therapies use masking sounds to reduce the impact of tinnitus, effectively blocking it out by matching the external sound to the internal and then by working out the sound level of the tinnitus to be able to work out the masking level to cover the tinnitus (Sandlin, et al., 1999). It is possible that masking occurred for the tinnitus group due to the background sound whereas the control group may have experienced the steady state as interfering noise consequently, impacting on their ability to concentrate. The control group performed better in both music conditions compared to the tinnitus group. For the tinnitus group it further illustrates ISE and the impact of acoustical variation. As their scores were lower in the disliked condition compared to the liked, it may also link in with the emotional salience of the music due to choosing their own preferred songs (Husain, et al., 2002).

The control group performed slightly better in the liked music condition compared with the quiet sound condition. This does not follow the pattern for most ISE studies which report a negative effect of sound, especially music (Perham & Sykora, 2012; Salame & Baddeley, 1999). Perham and Currie (2014) used liked and disliked lyrical music, as well as non-lyrical music and a quiet condition. They found that both the lyrical music conditions produced the most errors in recall, which is at odds with these results (Perham & Currie, 2014). Jones, et al. (1999) also found a significant negative effect of music when compared to the quiet condition. On the other hand, enjoyment, pace and tempo have been shown to mediate the effect of the music on the listener (Husain, et al., 2002). Cognitive performance has been shown to improve when listeners enjoyed the music; in this study, the participants choose their own ‘liked’ music which may have more impact than in previous studies where music is chosen for them (Husain, et al., 2002; Soh & Lim, 2013). In this study the music was not assessed for any quality other than it was familiar and liked by them as differences between groups and effect of ISE on the tinnitus group was the main aim. Again, slightly deviating from normal ISE research, the control group were marginally better at recall in the disliked music condition compared to the steady state. Further support for the improvement of recall in the presence of
background music comes from Angel, Polzella, and Elvers (2010), where a study of university students showed spatial processing speeds and accuracy improved compared to the no music condition.

Subjective scores show that both groups thought they would perform equally well in the quiet condition. The control group predicted that they would perform slightly better in the liked music but the tinnitus group predicted slightly worse performance when compared with the quiet condition. The tinnitus group showed reduced confidence in their ability with background liked music then steady state, followed by disliked music. This is different from Perham and Currie (2014) who found that the lyrical liked music, followed by quiet and then non-lyrical music were believed to be the best conditions to complete the reading comprehension task. Performance was actually best in the quiet and non-lyrical music and worst in the lyrical music conditions (Perham & Currie, 2014).

Within the other ratings, scores for likability and pleasantness of each condition were similar with the most disliked and unpleasant being disliked music and the most likeable and pleasant was liked music. Interestingly, the pleasantness ratings show that the control group found all sound conditions more pleasant than the tinnitus group. The level of distractibility in each condition was showed some noticeable differences between groups in the steady state condition. Both groups reported that the quiet state was the most distracting even though they also predicted that they would have the best recall scores in this sound condition. The tinnitus group felt that the steady state was the least distracting of all their ratings whereas, the control group rated steady state nearly 40% worse. The findings of how offensive the conditions are, were quite significant with both groups finding the steady state very offensive when compared to quiet state and liked music, a 40% difference again. The tinnitus group found the disliked music slightly worse and the control group found the disliked music slightly better than the steady state condition. The subjective scores were similarly patterned compared to their actual objective scores.

The extra information from the tinnitus group was not collated due to the lack of significant interaction between groups. Whilst completing the forms, the participants also verbalised their experiences of tinnitus and felt that it was important to share their stories of how they were affected and what their coping techniques were. This may be useful information in further research.
4.1. Limitations and future directions

There are a number of limitations to this study. The small sample scale may affect the strength of the results although, numbers were relatively equal. A larger group of participants with tinnitus may give stronger findings and potentially show group differences when compared with the control. This study did not assess the level or type of tinnitus before the study, so potential differences could not have been known about. Given the range of tinnitus sounds that are reported and their loudness, future research could use these differences to create groups of participants who share similar sounds, within the tinnitus group, to look for differences between them and the control group. The sound condition type and volume could also be adjusted as needed for equality between participants. This may show differences in cognitive ability within the tinnitus group or perhaps different responses in the sound conditions. Tinnitus is frequently linked to hearing loss which also was not accounted for, except that participants were not hearing aid users as the use of headphones would be more difficult. A hearing test could rule out any hearing loss that may affect future studies. It is believed that all participants had hearing with a normal range.

Another limitation relates to the liked music condition where participants choose their own preferred song. No analysis was carried out to look at tempo, mode or similarity between any music choices, this may have had an impact and measurements could be included in future studies. The effects of tinnitus appear to be wide ranging, affecting mental health, cognitive ability and social interactions (Lockwood, et al., 2002; Trevi, et al., 2016). The results of this study appear to show that all background sound has a negative impact on cognitive tasks than when completed the quiet which competes with the literature forwarding the positive accounts of music therapy or having music on in the background to reduce the effects of tinnitus (Hesse, 2016; British Tinnitus Association, 2018). If further research could show that tinnitus in quiet conditions does not affect ability in cognitive tasks and find out which sound conditions are helpful/ unhelpful, it may be possible to educate and empower people in managing their tinnitus proactively during times of cognitive load.

Lastly, any effect of tinnitus within ISE studies seems unclear from the results of this study therefore, further investigation would be necessary to this out conclusively.
4.2, In conclusion

This study appears to leave the reader with more questions than answers. The tinnitus group followed the traditional irrelevant sound effect study results with quiet being the most effective condition for recall, followed by steady state, liked and then disliked music. The control group/ non-tinnitus, performed best in the liked music condition followed by quiet, disliked music and then steady state. this does not follow the traditional pattern of recall task score. The tinnitus group achieved better recall in the quiet and steady state conditions when compared to the control group which was not expected. Although no significant interaction was found between groups, there were many interesting smaller differences where hopefully a larger sample may provide scope for significant results if applicable. All of these unexpected results are intriguing and will hopefully pave the way for further investigations between people with tinnitus and those without, in ISE research.
5. References


## WORD COUNT STATEMENT

<table>
<thead>
<tr>
<th>Section</th>
<th>WITHOUT REF.</th>
<th>WITH REF.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1897</td>
<td>2153</td>
</tr>
<tr>
<td>METHOD</td>
<td>695</td>
<td>699</td>
</tr>
<tr>
<td>RESULTS</td>
<td>661</td>
<td>661</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>1782</td>
<td>1836</td>
</tr>
<tr>
<td>TOTAL</td>
<td>5035</td>
<td>5349</td>
</tr>
</tbody>
</table>

Signed: [Signature]

Date: 19-4-2018