Making Things Easier by Making Them Harder: Can Listening at a Low Volume Improve Hearing?

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Making Things Easier By Making Them Harder: Can Listening at a Low Volume Improve Hearing?

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A Thesis in the Field of Psychology
for the Degree of Master of Liberal Arts in Extension Studies

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Abstract

Can listening to information at a low volume improve hearing? To test this hypothesis this experiment had undergraduate students listen to a podcast at a low volume. In addition, this study also explored expectation or priming someone to anticipate a particular outcome. The central questions of this study asked how both listening to a podcast at a low volume and expectation influenced hearing outcomes, reaction times, the comprehension of auditory information and perceived mindfulness. A secondary line of inquiry examined whether one’s perceived mindfulness is correlated with reaction times. To this end, 111 Harvard undergraduate students with no history of hearing impairment were recruited into a 2 x 2 factorial designed study, where podcast volume and expectation were the factors at play. All participants completed a Langer Mindfulness Scale and a hearing test before being placed into one of four conditions: condition 1, participants listened to a podcast at a regular volume and were told they could expect their hearing to improve, condition 2, participants listened to a podcast at a regular volume, condition 3, participants listened to a podcast at a low volume and were told that they could expect their hearing to improve, and condition 4, participants listened to a podcast at a low volume. Participants then completed a second Langer Mindfulness Scale and hearing test, as well as a visual reaction time test, an auditory reaction time test and a quiz designed to test participants’ comprehension of the podcast material.

This study found that participants that listened to podcasts at a low volume would experience improvements in their posttest hearing test scores.
Additionally, being within an expectation group was significantly associated with better scores on hearing tests. It should be noted that this study presupposed that listening to podcasts at a lower volume level will allow participants to mindfully notice change. Due to the fact that other mindfulness interventions have produced positive changes in auditory processing (Langer, 2009) this study’s results may give further credence to the notion that engaging in mindfulness can positively impact sensory processing. In light of these results it may be prudent to explore whether listening to information at a low volume can improve the hearing of those who live with mild to moderate hearing impairment.

Conversely, based on the analysis of this thesis the podcast volume and expectation were not significantly correlated with reaction times or perceived mindfulness. Similarly, perceived mindfulness was not significantly correlated with reaction times. Lastly, the comprehension assessment used to evaluate the comprehension of podcast material proved to be too easy. As a result, a ceiling effect was observed and thus whether listening to podcasts at a low volume impacts comprehension remains unknown.
Acknowledgments

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Chapter I

Introduction

Definition of Terms

Mindfulness- a flexible state of mind whereby an individual is actively engaged in the present by noticing novel stimuli while remaining sensitive to the immediate context that such stimuli is situated within (Langer & Moldoveanu, 2000).

Mindlessness- can be understood as a passive state of mind that relies on behaviors and patterns of thought that were established in the past (Langer, 2005).

Disfluency- deliberately makes information harder to process. An example could be making a text harder to read by using a font that is significantly smaller than standard text (Diemand-Yauman, Oppenheimer & Vaughan, 2010).

Hearing impairment- hearing that is below the medical standard of normal hearing. Threshold for normal hearing in adults is 40 dB HL (decibels per hearing level) or better for both ears whereas the threshold for children is 30 dB HL or better for both ears (World Health Organization [WHO], 2017).

Mind-body construct- a theory that postulates that a person’s body and their mental state are inseparable and thus profoundly influence one another (Langer, 2009).

Embodied cognition- the study of how external stimuli that acts upon the body influences an individual’s thoughts and decisions (Niedenthal, Barsalou, Winkielman, Krauth-Gruber & Ric, 2005).
Mindfulness

The term mindfulness can be traced back to the Buddhist word sati, which can be understood as the awareness of something’s essential qualities and how these qualities relate to a cosmic whole (Sharf, 2015). Stripped of its celestial underpinnings, the concept of mindfulness has been appropriated by the West since the late 1960’s. For instance, Kabat-Zinn defined mindfulness in the 70’s to mean an awareness that is brought about by intentionally paying attention to the present moment in a non-judgmental manner (Kabat-Zinn et al., 2003). Several contemporary interpretations of mindfulness have been posited since the 1960’s. For the purpose of this paper, Ellen Langer’s definition of mindfulness will be employed. This definition describes mindfulness as a flexible state of mind whereby an individual is actively engaged in the present by noticing novel stimuli while remaining sensitive to the immediate context (Langer, & Moldoveanu, 2000). Thus, this concept of mindfulness includes a person’s awareness of change.

Mindfulness vs Mindlessness

In order to understand mindfulness it is useful to evaluate its opposite—mindlessness. Mindlessness can be understood as a passive state of mind that relies on behaviors and patterns of thought that were established in the past (Langer, 2005). Thus, mindless states are characterized by a ridged perspective that is insensitive to the nuances of the present context (Langer, 2005). There are three primary ways that mindlessness can manifest itself. The first is by participating in habits or automatic behaviors that have
been established through repetition. A common example of this type of mindlessness is driving on autopilot only to realize that you have driven a considerable distance without being consciously aware of the journey. Secondly, a belief in limited resources can bring about a state of mindlessness through hindering a person’s ability to conceive of new possibilities (Langer, 2000). Finally, premature cognitive commitment whereby an individual becomes rigidly reliant on preexisting categories that were created in the past can also engender mindlessness. An injurious example of this form of mindlessness can be found when one judges an individual from a particular race based on negative racial stereotypes rather than evaluating the merits of the individual person.

According to Langer, mindlessness can levy a heavy cost. Loss of control, unintended cruelty, inhibited self-image and stunted potential are some of the detrimental effects mindlessness can have (Langer, 1989). This study attempts to counteract mindlessness whilst improving hearing abilities, reaction time and comprehension outcomes. To accomplish this goal, the study employed the construct of disfluency, whereby information is intentionally made harder to process (Diemand-Yauman et al., 2010). Specifically, disfluency was created by presenting auditory information at a low volume level. Based on Langer’s definition of mindfulness, listening to podcasts at a lower volume level will allow participants to mindfully notice change. The first change that a participant notices is the obvious drop in volume in comparison with the typical volume most listen to podcast with. Secondly, due to the additional attention that listening to a podcast at a low volume requires, it is hypothesized that participants will notice changes in the content being presented.
Intentional Disfluency

Disfluency can be defined as an impairment in the ability to produce or process information (Diemand-Yauman et al., 2010). In recent years, the construct of intentional disfluency, or deliberately making information harder to process, has been utilized as a means to improve learning outcomes. For instance, a 2010 study found that information presented in easy-to-read fonts was harder to recall than information presented in hard-to-read fonts (Diemand-Yauman et al., 2010). Within this study 222 high school students, ages 15 to 18 were recruited from a public school in Ohio. Six different classes within the school were utilized for the experiment. Different sections of each class were randomly assigned to either a disfluency condition where worksheets and PowerPoint presentations were presented in a difficult-to-read font, or to a control group where the material was presented in an easy-to-read font. The experiment ran the length of the classes’ lesson plans and ranged from a week and a half to a month. Assessment of the lesson plans’ material was administered by the respective teacher at the end of the unit. Students’ test scores were converted into Z-scores and the disfluency condition scored higher on assessments \((M = 0.164, SD = 1.03)\) when compared to control groups \((M = -0.295, SD = 1.03)\).

Similarly, another study aimed to detect the effect of disfluency on processing styles, discovered that written information presented in a disfluent manner was more likely to produce a slower processing style characterized by systematic analytical reasoning, and that such reasoning was found to be conducive to error detections (Alter, Oppenheimer, Epley & Eyre, 2007). Within this study 40 undergraduate students from
Princeton were recruited. Participants completed the Cognitive Reflection Test, an assessment that consists of three items where the initial and intuitive reaction is incorrect but the correct answer can be arrived at through deliberate reflection. Students were randomly assigned to either a disfluency group where participants’ Cognitive Reflection Test was presented in a difficult-to-read font or a control group where the test was unaltered. Participants within the disfluent condition scored higher on the Cognitive Reflection Test ($M = 2.45, SD = 0.64$) than those in the control group ($M = 1.90, SD = 0.89$). In fact, only 35% of participants in the disfluent condition answered one or more questions incorrectly, whereas 90% of participants in the control group did so.

However, not all research on disfluency has garnered positive results. A 2016 study revealed that, in regards to the retention and transfer of information, high-test expectancy led to better learning outcomes while disfluency in the form of difficult-to-read font did not (Eitel & Kühl, 2016). Within this study 97 undergraduate students from a German University were randomly assigned into one of four conditions within a 2 x 2 study design with text legibility (easy-to-read font vs. difficult-to-read font) and test expectancy (low vs. high) as the between-subjects factors. All subjects were given the same article to read and were then tested on the retention of that material. All material and assessment were given in German. Students who were told at the start of the study that they would be tested on the material (high-test expectancy), outperformed students who were not told that they would be tested on the material (low-test expectancy). There was no main effect of text legibility, nor did the interaction between text legibility and test expectancy reach statistical significance. Though these conflicting accounts of the effectiveness of intentional disfluency may be the result of differences between the
German and English language, further research on this topic would benefit the overall understanding of the effects of disfluency.

An area of sensory processing that could potentially benefit from a clearer understanding of disfluency is that of auditory processing. Given that there is some evidence to suggest that visual disfluency can improve comprehension, it is worth exploring whether auditory disfluency, or intentionally making information harder to process by reducing the volume of the auditory information, can have a positive impact on comprehension. Consequently, this study hypothesized that, in regards to comprehension assessments, participants placed in conditions where they listen to information at a lower volume would outperform participants placed in conditions where information is present at a normal volume.

Hearing

According to the World Health Organization [WHO], a person is classified as having a hearing impairment if their hearing is below the medical standard of normal hearing. Threshold for normal hearing in adults is 40 dB HL (decibels per hearing level) or better for both ears whereas the threshold for children is 30 dB HL or better for both ears (WHO, 2017). Hearing impairment can be the result of congenital causes such as low birth rate or maternal rubella during pregnancy, or it can be the result of acquired causes, such as the contraction of an infectious disease, exposure to excessively loud sounds or ageing (WHO, 2017). Moreover, some research indicates that hearing loss can be the result of psychosocial constructs, such as internalized stereotypes that assume that hearing loss will occur as one ages. Age stereotypes were examined with 546 adults aged
It was discovered that individuals who held more negative age related stereotypes exhibited greater hearing loss 36 months later (Levy, Slade & Gill, 2006).

It is currently estimated that 360 million people worldwide suffer from some form of hearing impairment, and that 32 million of these individuals are children (WHO, 2017). Additionally, it is estimated that one third of people above 65 years old suffer from debilitating hearing loss (WHO, 2017). Hearing impairment can be profound, in the case of deafness, severe, moderate, or mild and causes difficulty in hearing conversational speech and sounds in general (WHO, 2017).

The impact of hearing impairment can be far reaching. Functionally, hearing impairment impedes an individual’s ability to communicate through spoken language. When hearing impairment is experienced in early childhood, it can lead to delays and deficiencies in spoken language development in general (WHO, 2017). Additionally, hearing impairment can exact an emotional and social toll. Often excluded from social communication, individuals who live with hearing impairments are susceptible to feelings of loneliness, isolation and frustration, thus reducing an individual’s quality of life (WHO, 2017). The effects of hearing impairment can have economic consequences as well. The WHO estimates that unaddressed hearing loss annually cost 750 billion dollars globally. This cost includes loss of productivity, cost of educational support and health sector costs (excluding the costs of hearing devices; WHO, 2017).

Current Trends in Treating Hearing Impairment
The most effective defense against hearing loss is prevention. In fact, the World Health Organization estimates that half of all cases of hearing loss are preventable through public health measures. These measures include, immunizations, effective prenatal care, effective treatment for both chronic and acute ear conditions, avoiding the use of ototoxic drugs, referring infants for early hearing assessments, reduced occupational and recreational exposure to loud noises and education regarding healthy ear and hearing care habits (WHO, 2017).

For those with hearing impairment there are treatment options available. Hearing aids are commonly prescribed to those who live with moderate to severe hearing loss. In developing countries, approximately 20% of people with hearing loss require hearing aids (WHO, 2017). Furthermore, a 2008 study found that 34.25 million Americans live with hearing loss and that 24.6% of that population uses a hearing aid (Kochkin, 2009).

Depending on the cause and extent of hearing loss additional treatment options are available and include cochlear implants whereby a small receiver is implanted under the skin and into a person’s cochlea in order to stimulate hearing (Schwartz, Watson & Backous, 2012), corticosteroid drug therapy, which is used to treat Idiopathic Sudden Sensorineural Hearing Loss (Wilson, Byl, & Laird, 1980) and stapedectomy ear surgery that treats hearing loss caused by a buildup of bone around the inner ear (Persson, And & Magnuson, 1997).

In spite of the various treatment options for hearing loss, hearing impairment itself remains difficult to treat, and many of the treatments improve but do not eliminate hearing difficulties. The most widespread treatment for hearing loss, hearing aids, do not eliminate the hearing loss. Rather, hearing aids merely augment an individual’s hearing.
by placing a device in a person’s ear that functions as a microphone, amplifier and speaker (Kochkin, 2009). Consequently, a person’s actual ability to hear does not change (Pichora-Fuller & Singh, 2006). While hearing aids allow many to decipher sounds that would otherwise be inaudible, hearing aids often amplify unwanted background noise (Nabelek, Tucker & Letowski, 1991) and cannot function in wet environments like one’s shower. Additionally, many do not have access to hearing aids. For instance, in developing countries, approximately 20% of people with hearing loss require hearing aids, however, it is estimated that less than 3% of these individuals have access to hearing aids due to cost and access to medical care (WHO, 2013).

The Mind-Body Construct

Due to the prevalence of hearing loss and its personal and global impact, as well as the limitations of current treatment options, alternative treatment modalities for hearing impairment are needed. One possibility is auditory dysfluency or listening to information at a lower volume. Listening to information at a lower volume forces its practitioners to pay closer attention to the stimulus at hand, thus allowing them to mindfully notice change. Mindfulness has been shown, in certain circumstance, to improve the physiology of the body (Langer, 2009). The mechanism by which mindfulness accomplishes this feat is best explained through the mind-body construct.

The mind-body construct postulates that a person’s body and their mental state are inseparable and thus profoundly influence one another (Langer, 2009). Under this hypothesis, the mind can exert a powerful influence over the body and its physiological processes. As a result, psychological interventions can bring about changes in physical
health (Langer, 2009). Research concerning the powerful effects of placebos gives
credence to this construct. Studies have shown that placebos have improved the health
outcomes of individuals with multiple sclerosis, Parkinson, and epilepsy (Haas, Fink &
Hartfelder, 1959).

Research concerning embodied cognition provides further support of the mind-
body construct. Embodied cognition is the study of how external stimuli that acts upon
the body impacts an individual’s thoughts and decisions (Niedenthal et al., 2005). An
exemplary illustration of embodied cognition can be found in the work of Michael Häfner
(2013). He asked participants to complete a questionnaire that compared units of money.
In the experimental condition participants were required to hold a small weight in their
hands while completing the survey. He found that the participants who held the weight
overestimated the units of money when compared to the control group. Other interesting
examples of embodied cognition support the biological observation that the insular cortex
is implicated in processing both psychological concepts of warmth, such as
trustworthiness and caring, as well as physical warmth (Meyer-Lindenberg, 2008). In one
study 41 undergraduate students were randomly assigned to either hold a hot or cold cup
of coffee before rating the personality of a fictional character. Students that held the hot
cup of coffee rated the character as having a “warmer” personality (generous, caring),
compared to those who held the cold cup of coffee (Williams & Bargh, 2008).
Additionally, the same research team found that participants that held a hot therapeutic
pad were more likely to choose a gift for a friend instead of for themselves when
compared to participants that held a cold therapeutic pad (Williams & Bargh, 2008).
These simple experiments highlight the interwoven nature that exists between mental states and physiology.

Perhaps Ellen Langer’s counterclockwise study is the most notable example of the interdependent connection between the mind and body. Within this study, Langer used mindfulness to induce a younger mindset in older adults. Inducing such a mindset was accomplished by inviting elderly men to a weeklong retreat where participants stayed in a home that was decorated as if it were 20 years earlier. Once there, participants were instructed to act as if it was 1959. Consequently, participants spoke of events that happened in 1959 as if they were current, and refrained from mentioning anything that took place after that year. Additionally, researchers facilitated daily discussions about ‘current events’ that included Castro’s advance on Havana and the need for bomb shelters. To further aid in the immersion of the 1950’s researchers also provided participants with magazines, movies, music and television programs from 1959. This allowed the men to engage in a mindset that was 20 years younger than their chronological age (Langer, 2009).

Participants completed a battery of assessments both before and after the retreat. These assessments tested both cognitive and physical agility. After completing the counterclockwise intervention, manual dexterity, posture, gait, strength, memory, cognition, taste sensitive, vision and hearing significantly improved. Additionally, external raters judged photos of participants both before and after their intervention. These raters found that participants who were in the experimental condition looked significantly younger after the intervention when compared to their before-treatment
Such striking results underscore the powerful effect that mindfulness-based interventions can have on physiology.

This current project also posits the existence of a mind-body construct and thus postulates that the mind and the body are inextricably bound to the point where the mind can powerfully influence the physiology of the body (Langer, 2009). Langer’s Counterclockwise study utilized a mindfulness intervention that precipitated improvements in a variety of physical dimensions, including hearing (Langer, 2009). Consequently, this study hypothesizes that inducing the mindful element of noticing change through listening to podcasts at a lower volume will result in improvements to hearing outcomes.

Reaction Time

Reaction time can be defined as the rapid and appropriate voluntary response by a subject to a stimulus (Gandhi, Gokhale, Mehta & Shah, 2013). It is composed of three basic elements: stimulus processing, decision making, and response programming (Das, Gandhi & Mondal, 1997). Reaction time can also be thought of as the performance of an individual in regards to their sensorimotor association (Shenvi & Balasubramanian, 1994). Additionally, an individual’s reaction time can be modeled in the following manner (Gandhi et al., 2013):

Stimulus → Sensory Neuron → Spinal Cord or Brain → Motor Neuron → Response.

Reaction time plays a critical role in many important tasks such as driving a vehicle. It can also play a crucial part in combat, emergency medicine, as well as in law enforcement and firefighting. Due to the important role reaction time plays in routine and
specialized tasks, exploring novel ways to improve reaction time would be a benefit to society at large. Thus, examining interventions that incorporate elements of mindfulness as potential mechanisms for improving reaction time is a worthwhile endeavor.

Interestingly, reaction time itself can be thought of as a measure of mindfulness for reaction time measures an individual’s awareness and response to change. A particular form of mindfulness—meditation, has been evaluated as a means to improve reaction times. Prashant Kaul and colleagues (2010) conducted a study to assess how meditation impacted participants’ reaction time by administering the psychomotor vigilance task before and after meditation. The psychomotor vigilance task asks subjects to monitor a LED display and hit a button as soon as a number appears on the display. This procedure is repeated at random intervals over the course of ten minutes (Kaul, Passafiume, Sargent, & O'Hara, 2010). Neurological studies of the psychomotor vigilance task indicate that optimal performance on this task relies on the activation of the motor system, as well as the sustained attention system (Drummond, Dinges, Ayalon, Mednick & Meloy, 2005). Within Kaul’s study, psychomotor vigilance task reaction times were assessed on seven different days. For six days, novice meditators were given the reaction time task before and after 40 minutes periods of meditation, nap, or a control activity. The seventh day of the trial assessed participants’ psychomotor vigilance task reaction time directly following a night of sleep deprivation and then again after 40 minutes of meditation. Analysis of the psychomotor vigilance task reaction times revealed that reaction times improved immediately following the periods of meditation, both in normal conditions, as well as in a sleep deprived state (Kaul et al., 2010).
Such findings help to justify the inclusion of both the Simple Auditory Reaction Time Test and the Simple Visual Reaction Time Test from the Millisecond Test Library within the post assessments of the current study. The hypothesis concerning reaction time is as follows: participants that listen to podcasts at lower volumes will be more apt to notice change in regards to the reaction time test stimuli and will thus have faster reaction times than the participants who listen to podcasts at regular volumes. I hypothesize that, though the current intervention only targets the auditory system, gains in reaction times may generalize to the visual system as well. Similarly, a secondary hypothesis of the study is that there will be a statistically significant correlation between both the Langer Mindfulness Scale and the Simple Visual Reaction Time Test scores, as well as the Langer Mindfulness Scale and the Simple Auditory Reaction Time Test scores.

Placebo and Expectation

The term “placebo” was first coined by the English physician, Alexander Sutherland in the mid-18th century. Sutherland recounted prescribing inert drugs “to satisfy the patient's mind,” when direct treatment of a patient’s ailment was not possible. Surprised, Sutherland noted that sometimes these inert treatments would produce a positive effect on his patients’ health (Jütte, 2013). In this way, a placebo can be thought of as a beneficial health outcome that results from an individual’s anticipation and belief that a particular intervention—procedure or pill, for example—will improve health outcomes.

Expectation Theory posits that placebo effects are a product of expectations. Through this lens, placebo effects are mediated by explicit expectancies (Stewart-
Evidence to support the positive impacts of placebos are varied, as they cover many different conditions. For instance, when placebo pills were compared with no-treatment for depression, a meta-analysis concluded that at least 50% of the short-term response to antidepressants was a placebo effect (Kirsch, & Sapirstein, 1999). Similarly, in clinical studies, the utilization of placebos has resulted in significant improvements in Irritable Bowel Syndrome symptoms (Kaptchuk et al, 2010). Research has also indicted that placebos have produced analgesia for individuals who experience pain, whether it be pain that is brought on intentionally in an experimental setting (Benedetti, Amanzio, Baldi, Casadio & Maggi, 1999) or pain resulting from chronic headaches (de Craen, Tijssen, de Gans & Kleijnen, 2000). Investigation into the neurological mechanisms that underpins the placebo effect have found that increased activation of the orbitofrontal cortex, which connects to the reward processing center of the brain (Jensen et al., 2015), and higher concentrations of endorphins in the cerebral spinal fluid (Lipman et al., 1990) are associated with the activation of placebo induced analgesia.

Interestingly, there is some evidence to suggest that placebos can impact a person’s auditory experience. A study examined the impact of participants’ expectations by comparing two behind-the-ear hearing aids (Dawes, Powell & Munro, 2011). The hearing aids themselves were identical except that one was called a “conventional” hearing aid and the other was referred to as a “new” hearing aid. Within the study, 20 adult hearing aid users compared the “new” and “conventional” hearing aid. Participants attended a single test session where they were fitted with the hearing aids before completing a sound quality rating for six different sound samples which included music,
speech and environmental sounds. Consistently, the “new” hearing aid was rated higher on all sound quality rating ($p < 0.01$), indicating that participants believed they were able to hear better when using the “new” hearing aid (Dawes et al., 2011). It is important to note that this study did not test the hearing abilities of the participants, perhaps this is because the notion that hearing cannot improve is so ingrained that some might see employing hearing tests in this context as a waste of resources.

Placebos have not been found to be effective in all hearing studies, however. For instance, a study used a placebo to examine the impact of ingesting the supplement gingko biloba on tinnitus. Tinnitus can be defined as a persistent sensation of hearing sound, often a ringing in one’s ear, when no external sound is present (Holgers, Zöger & Svedlund, 2005). Often related to hearing loss, tinnitus is not a condition itself but is a symptom of an underlying condition, such as an ear injury (Holgers et al., 2005). In this double blind, placebo-controlled trial 978 participants with tinnitus were randomly assigned either to a treatment group where they were given 50 mg of gingko biloba 3 times a day for 12 weeks or to a placebo control where they ingested inert pills at the same rate. When participants pre-intervention and post-intervention subjective hearing was compared, there was no significant difference in either the gingko biloba condition or the placebo control condition (Drew & Davies, 2001). These findings may be due to the fact that this study was meant to explore tinnitus rather than hearing ability specifically and thus participants may have expected their tinnitus to improve rather than their hearing ability to improve. However, it should be noted that only 34 of 360 participants receiving gingko biloba reported improvements to their tinnitus while similarly, 35 of
360 participants receiving placebos reported comparable improvements (Drew & Davies, 2001).

Due to the limited and inconsistent findings regarding the placebo’s impact on hearing outcomes the impact of expectation was explored in this study. Specifically, within the 2 x 2 factorial design, the two independent variables that were tested were podcast volume and expectation. Within conditions that explored expectation, participants were told that they could expect their hearing to improve as a result of their condition’s intervention. Due to the positive impact placebos have had on other conditions, I hypothesized that participants who were placed into a condition where they were told to expect their hearing to improve would outperform participants who were placed in conditions where there was no expectation.
Chapter 2

Methods

Participants

One hundred and eleven Harvard students were recruited from the Harvard Department of Psychology Study Pool through an advertisement on SONA (See Appendix 1: Recruitment Material: SONA Advertisement). When students signed up for the study through SONA they were asked to state their age, if they had been diagnosed with a hearing impairment and if they had a smartphone. In order for someone to be included in this study they had to be an undergraduate student at Harvard University, between the ages of 18 and 35 years old, free of a diagnosed hearing impairment, and had access to a smart phone for the duration of the study. Individuals were excluded from the study if they were not Harvard undergraduate students, had been diagnosis with a hearing impairment, and did not have access to a smartphone for the duration of the study.

Additionally, participants were recruited under the incomplete pretense that this study aims to learn more about the way in which individuals uniquely process information. This incomplete description of the study’s aims was necessary to ensure that participants’ responses were not biased by the study’s hypotheses.

Procedures

Informed Consent
The study took place in room 809 of William James Hall. Participants were greeted in the 8th floor lobby by an RA before they were escorted into room 809. There a research assistant provided the participant two copies of the informed consent (see Appendix 2: Informed Consent). The RA collected one copy of the informed consent for the study’s records and the second copy was given to the participant to keep. The RA also offered to answer any questions that the participant had in regards to the informed consent form.

Baseline Measurements: Initial Hearing Screening

Participants then had their hearing tested through the use of the Hearza app, which is an app specifically designed to test and score a person’s hearing. To ensure that every participant receives the same experience, all participants used the same headphones. To use the Hearza app participants followed the prompts provided by the app (see Appendix 3: Assessment Materials: Herza Screen Shots). During the hearing test the app stated a series of numbers at various volumes and the participant typed in the numbers that they believed they heard. At the end of the hearing test, the app provided a hearing score to the participant. The RA then recorded the participant’s initial hearing score.

Baseline Measurements: Survey Packet

Participants were then asked to fill out two brief surveys on a laptop computer. This series of surveys included:

Demographic survey. Participants were asked to report gender, date of birth and if they are currently a freshman, sophomore, junior or senior.
**Langer mindfulness scale.** This scale assesses a participant on multiple dimensions: openness to new experiences, oriented to the present moment, the degree to which one is cognizant of distinctions, awareness of multiple perspectives and sensitivity to changing contexts. This 21-item survey is divided into three categories, which include, novelty seeking, novelty-producing and engagement. The Langer Mindfulness Scale aims to assess mindfulness through the use of a 7-point Likert Scale. This scale ranges from 1 (strongly disagree) to 7 (strongly agree). Higher scores indicate a greater degree of mindfulness and takes 5 to 10 minutes to complete (Pirson, Langer, Zilcha & Bodner, 2012).

**Hearing Intervention**

After completing the survey, participants were asked to select one of four podcasts to listen to (see Appendix 4: Hearing Intervention Materials: Podcast Descriptions). Each podcast covered a different topic and those topics included sports, international relations, psychology, and self-improvement through the use of technology. Each podcast was approximately 30 minutes long. Special care was taken to choose podcasts that covered stories unfamiliar to the public at large.

Once participants had chosen their podcast, the RA provided them with instructions to one of four conditions. All participants were randomly assigned to their condition before they arrived at the lab. The four conditions were as followed: **Condition 1 (regular volume x expectation).** Before listening to a podcast, participants were told that they could expect their hearing to improve as the result of listening to a
podcast of their choosing. They were then instructed to listen to a podcast of their choosing at a normal volume, on headphones, for 30 minutes.

**Condition 2 (regular volume x no expectation).** In this condition, participants were instructed to listen to a podcast of their choosing at a normal volume, on headphones, for 30 minutes.

**Condition 3 (low volume x expectation).** Before listening to a podcast, participants were told that they could expect their hearing to improve as the result of listening to a podcast at a low volume. They were then instructed to listen to a podcast of their choosing, at a very low volume, on headphones for 30 minutes.

**Condition 4 (low volume x no expectation).** In this condition, participants were instructed to listen to a podcast of their choosing, at a very low volume, on headphones for 30 minutes.

**Table 1**

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Baseline Measurements</th>
<th>Podcast with Low Volume</th>
<th>Podcast with Regular Volume</th>
<th>Expectations</th>
<th>Post Intervention Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition 1</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Condition 2</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Condition 3</td>
<td>X</td>
<td>X</td>
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<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Condition 4</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Once the RA provided the participant with the appropriate instructions the RA then setup the podcast on the laboratory’s iPad. The RA ensured that the iPad was at the appropriate volume level for the condition. The iPad’s child locks were enabled so that the participant could not change the volume of the podcast. The participant was given
both the iPad and headphones provided by the lab. The RA then told the participant that they will be in the room next door and asked the participant to get them when they were finished listening to the podcast.

Post Intervention Measurements: Repeated Measures

When the participant was finished listening to their respective podcast, the RA assessed their hearing for the second time with the Hearza app. Once the participant completed the hearing test, the RA recorded the score. Additionally, the participant was asked to complete the Langer Mindfulness Scale for the second time.

Post Intervention Measurement: Podcast Assessment

The RA then asked participants to take a brief quiz aimed to assess the participant’s comprehension of the podcast. Four different quizzes were created, one for each podcast (see Appendix 5: Post Intervention Materials: Podcast Comprehension Assessment). Each quiz asked three multiple choice questions followed by two short answer questions.

Post Intervention Measurement: Reaction Time Tests

Additionally, participants were asked to complete the Simple Auditory Reaction Time Test and the Simple Visual Reaction Time Test form the Millisecond Test Library. Both assessments were taken on the lab’s laptop. The Simple Auditory Reaction Time Test instructed participants to press the spacebar as soon as they heard a tone, while the
Simple Visual Reaction Time Test instructed the participants to press the spacebar as soon as they saw a circle on the computer screen.

Debriefing

After the participant finished the podcast assessment they were informed that the study had concluded. At this point, the RA thanked them for their participation and provided the participant with a copy of the debriefing form (see Appendix 6: Debriefing Form). The debriefing form explained the study’s hypothesis, provided background on disfluency (making information harder to process), briefly outlined the study’s design and provided participants with the contact information of both the researchers and the Committee on the Use of Human Subjects in Research. The contact information was to be used in the event that the participant had any questions or concerns as to their rights as a participant. In addition, the debriefing form alerted the participant to the fact that they were recruited into the study under incomplete pretenses and that this was necessary to ensure that the participant’s response would not be biased by the study’s hypothesis. The RA also offered to answer any questions that the participant had at the end of the study.
Chapter III

Results

Participants

The final sample included in this study consisted of 111 participants. All participants were randomly assigned to one of four groups: condition 1 (regular volume x expectation), condition 2 (regular volume x no expectation), condition 3 (low volume x expectation) and condition 4 (low volume x no expectation). Twenty-eight participants were placed in condition 1, twenty-eight participants were placed in condition 2, twenty-eight participants were placed in condition 3 and twenty-seven participants were placed in condition 4.

In condition 1 (regular volume x expectation), participants’ ages ranged from 18 to 24 years old, with the average age being 19.92 years ($SD = 1.30$). There were 16 males, 11 females and one participant who chose not to identify their gender within this group. In condition 2 (regular volume x no expectation), participants’ ages ranged from 18 to 22 years old, with the average age being 19.53 ($SD = 1.23$). There were 14 females and 14 males within condition 2. In condition 3 (low volume x expectation), participants’ ages ranged from 18 to 28 years old, with the average age being 20.1 ($SD = 2.49$). There were 22 females and 6 males within this group. Finally, condition 4 (low volume x no expectation), participants’ ages ranged from 18 to 34 years old, with the average age being 20.29 ($SD = 3.29$). There were 11 males, 15 females and one participant who chose not to identify their gender, within this group. Taken collectively, the age range for all participants was 18 to 34 years old, with the average age being 19.96 ($SD = 2.22$). For all
conditions, 42 participants were male, 67 participants were female and 2 participants chose not to identify their gender.

Table 2

Demographic Analysis

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Mean Age (Years)</th>
<th>Mean Standard Deviation</th>
<th>Number of Males</th>
<th>Number of Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Regular Volume x Expectation</td>
<td>19.92</td>
<td>1.3</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>2) Regular Volume x No Expectation</td>
<td>19.53</td>
<td>1.23</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>3) Low Volume x Expectation</td>
<td>20.10</td>
<td>2.49</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>4) Low Volume x No Expectation</td>
<td>20.20</td>
<td>3.29</td>
<td>11</td>
<td>15</td>
</tr>
</tbody>
</table>

Impact of Volume and Expectation on Hearing

In regards to hearing outcomes this study held two hypotheses: 1) that listening to podcasts at a lower volume level will allow participants to mindfully notice change and this would result in improvements to hearing outcomes and 2) that participants who were placed into a condition where they were told to expect their hearing to improve would outperform participants who were placed in conditions where there was no expectation. In order to test these hypotheses a factorial ANOVA was conducted to determine the main effects of volume level of podcast and expectation on hearing outcomes.

After outliers and assumptions were inspected a factorial ANOVA was conducted to compare the main effects of expectation, volume level and the interaction effect between expectation and volume level on hearing test scores. For this factorial ANOVA posttest hearing scores were the dependent variable and pretest hearing scores were
utilized as a covariate. A two-way analysis of variance was conducted on the influence of two independent variables (expectation and volume) on the posttest hearing scores. Expectation type consisted of two levels (expectation and no expectation) and volume involved two levels also (normal volume and low volume). As anticipated by our hypothesis, the effects were statistically significant for volume level at the .05 significance level. Similarly, based on a one tailed prediction effects were significant for expectation at the .10 significant level. The main effect for volume type yielded an F ratio of $F(1, 98) = 6.190$, $p = .015$, partial $\eta^2 = .059$, indicating a significant difference between low volume ($M = 70.62$, $SD = 6.319$) and regular volume ($M = 67.66$, $SD = 6.721$) in regards to posttest hearing scores. The difference between the mean hearing test scores for low volume ($M = 70.62$) and regular volume ($M = 67.66$) indicates that participants assigned to conditions that incorporated low volume, on average, performed better on posttest hearing scores than participants assigned to conditions with regular volume. The main effect for expectation yielded an $F$ ratio of $F(1, 98) = 3.580$, $p = .061$, and partial $\eta^2 = .035$, indicating a significant difference between expectation ($M = 70.69$, $SD = 6.58$) and no expectation ($M = 67.65$, $SD = 6.424$) in regard to posttest hearing scores. The difference between the mean hearing test scores for expectation ($M = 70.69$) and no expectation ($M = 67.65$) indicates that participants assigned to conditions that incorporated expectation, on average, performed better on posttest hearing scores than participants assigned to conditions with no expectation, based on a one tailed prediction significance level of .10. Conversely, the interaction effect was not significant, $F(1, 98) = 3.687$, $p = .058$, partial $\eta^2 = .036$, indicating that the effect of volume on hearing test scores was not significantly greater in the expectation conditions when compared to the
non-expectation conditions. Similarly, the effect of expectation on hearing test scores was not significantly greater in the low volume conditions when compared to the regular volume conditions. Additionally, a pairwise comparison of the four conditions found that the average hearing score of condition 3, (low volume x expectation) ($M = 72.6$) was significantly higher than all other conditions (condition 1 $M = 67.73$, condition 2 $M = 67.238$ and condition 4 $M = 68.35$). The pairwise comparison between all other conditions was found not to be statistically significant.

Additionally, regression analyses were also conducted to determine if there was a significant correlation between low volume and better hearing scores, as well as expectation and better hearing scores. The analysis revealed that being in an expectation group was significantly associated with better scores on the hearing test, $t(104) = 2.304, p = .023$. Similarly, being in a low volume group was significantly associated with better scores on the hearing test, $t(104) = 2.241, p = .027$. 
Figure 1: Illustrates that the interaction between Volume and Expectation was not significant. Note that volume in this graph is labeled as “Disfluency.” Disfluency is the act of deliberately making information harder to process. In this case disfluency refers to making auditory information harder to process by lowering the volume.
Impact of Volume and Expectation on Mindfulness

In regards to the Langer Mindfulness Scale 21 (LMS-21) posttest scores this study hypothesized that inducing the mindful component of noticing change through listening to a podcast at a low volume would result in improvements to LMS-21 posttest scores. Conversely, this study did not expect expectation to impact the LMS-21 posttest scores. In order to test these hypotheses a factorial ANOVA was conducted to determine the main effects of volume and expectation on LMS-21 posttest scores.

After outliers and assumptions were inspected a factorial ANOVA was conducted to compare the main effects of expectation and volume and the interaction effect between expectation and volume on LMS-21 scores. For this factorial ANOVA posttest LMS-21 scores were the dependent variable and LMS-21 pretest scores were utilized as a covariate. Thus, a two-way analysis of variance was conducted on the influence of two independent variables (expectation and volume) on the posttest LMS-21 scores. Expectation type consisted of two levels (expectation and no expectation), while volume involved two levels also (normal volume and low volume). Contrary to this study’s hypothesis, the effects were not statistically significant for volume at the .05 significance level. Conversely, the fact that effects were not statistically significant for expectation was in line with this study’s hypothesis. The main effect for volume type yielded an F ratio of $F(1, 96) = .017, \ p = .897$, partial $\eta^2 = .000$. Thus, there was no significant difference between low volume ($M = 111.94, SD = 11.76$) and regular volume ($M = 112.02, SD = 12.03$) in regards to posttest LMS-21 scores. The main effect for
expectation yielded an $F$ ratio of $F(1, 96) = .163$, $p = .668$, and partial $\eta^2 = .002$, indicating no significant difference between expectation ($M = 112.67$, $SD = 11.22$) and no expectation ($M = 111.33$, $SD = 12.47$) in regards to posttest LMS-21 scores. Similarly, the interaction effect was not significant, $F(1, 96) = .092$, $p = .762$, partial $\eta^2 = .001$.

Impact of Volume and Expectation on Auditory Reaction Time

This study hypothesized that participants who listened to their podcast at a low volume would have faster auditory reaction times than the participants who were placed in the regular volume conditions. Conversely, this study did not anticipate that expectation would have any impact on auditory reaction times.

After outliers and assumptions were inspected a factorial ANOVA was conducted to compare the main effects of expectation, volume and the interaction effect between expectation and volume on Simple Auditory Reaction Time Test scores. Thus, a two-way analysis of variance was conducted on the influence of two independent variables (expectation and volume) on the Simple Auditory Reaction Time Test scores. Expectation type consisted of two levels (expectation and no expectation) and volume involved two levels also (normal volume and low volume). Contrary to the hypothesis, effects were not statistically significant for volume at the .05 significance level. However, as anticipated, effects were not statistically significant for expectation also. The main effect for volume type yielded an $F$ ratio of $F(1, 90) = .151$, $p = .699$, partial $\eta^2 = .002$. Thus, there was no significant difference between low volume ($M = 258.47$, $SD = 38.72$) and regular volume ($M = 261.18$, $SD = 29.38$) in regards to the Simple Auditory Reaction Time Test scores. The main effect for expectation yielded an $F$ ratio of $F(1, 97) = 1.128$,
\[ p = .291, \text{ partial } \eta^2 = .011, \text{ indicating no significant difference between expectation } (M = 260.11, SD = 32.99) \text{ and no expectation } (M = 259.43, SD = 36.06) \text{ in regards to the Simple Auditory Reaction Time Test scores. Similarly, the interaction effect was not significant, } F(1, 90) = .350, p = .556, \text{ partial } \eta^2 = .004. \]

The Impact of Volume and Expectation on Visual Reaction Time

This study hypothesized that participants within the low volume conditions, conditions designed to induce the mindfulness element of noticing change, will have faster visual reaction times than the participants who were placed in the regular volume condition. Conversely, this study did not anticipate that expectation would have any impact on visual reaction times.

After outliers and assumptions were inspected a factorial ANOVA was conducted to compare the main effects of expectation, volume and the interaction effect between expectation and volume on Simple Visual Reaction Time Test scores. Thus, a two-way analysis of variance was conducted on the influence of two independent variables (expectation and volume) on the Simple Visual Reaction Time Test scores. Expectation type consisted of two levels (expectation and no expectation) and volume involved two levels also (normal volume and low volume). Contrary to my hypothesis, the effects were not statistically significant for volume at the .05 significance level. However, as anticipated, the effects were also not statistically significant for expectation. The main effect for volume type yielded an F ratio of \( F(1, 97) = 2.136, p = .147, \text{ partial } \eta^2 = .022. \) Thus, there was no significant difference between low volume \( (M = 294.38, SD = 41.90) \).
and regular volume ($M = 307.91, SD = 49.64$) in regards to the Simple Visual Reaction Time Test scores. The main effect for expectation yielded an $F$ ratio of $F(1, 97) = 1.128$, $p = .291$, partial $\eta^2 = .011$, indicating no significant difference between expectation ($M = 305.75, SD = 51.73$) and no expectation ($M = 296.04, SD = 39.45$) in regards to the Simple Visual Reaction Time Test scores. Similarly, the interaction effect was not significant, $F(1, 97) = .257, p = .614$, partial $\eta^2 = .003$.

**Mindfulness and Auditory Reaction Time Correlational Analysis**

A secondary hypothesis of the study was that there would be a statistically significant correlation between the Langer Mindfulness Scale scores (LMS-21) and reaction time tasks scores. To this end, a Spearman Correlation Analysis was conducted to determine if there was a relationship between the pretest LMS-21 scores and mean Simple Auditory Reaction Time Test scores.

After outliers and assumptions were inspected a Spearman Correlation Analysis was conducted. There was no statistically significant correlation between the Langer Mindfulness Scale and the Simple Auditory Reaction Time Test scores ($p = .251$). Consequently, the increases or decreases in the LMS-21 scores do not significantly predict increases or decreases in the Simple Auditory Reaction Test scores or vice versa.

In addition, a series of t-tests were run to determine if faster reaction times were associated with higher mindfulness scores overall and within particular conditions. In regards to our total pool of participants, of those who scored in the top one third of the fastest auditory reaction times also scored higher on LMS-21 mindfulness measure ($M =$
112.61, $SE = 2.56$) than those who scored in the slowest two thirds of auditory reaction times ($M = 111.43, SE = 1.54$). However, this difference was not statistically significant, $t(92) = .410, p = .683$.

Similarly, for participants in the expectation only conditions, of those who scored in the top one third of the fastest auditory reaction times also scored lower on the LMS-21 mindfulness measure ($M = 108.14, SE = 4.30$) than those who scored in the slowest two thirds of auditory reaction times ($M = 113.20, SE = 3.46$). However, this difference was not statistically significant, $t(20) = -.846, p = .407$.

On average, for participants in the low volume only conditions, of those who scored in the top one third of the fastest auditory reaction times also scored higher on the LMS-21 mindfulness measure ($M = 119.00, SE = 5.99$) than those who scored in the slowest two thirds of auditory reaction times ($M = 112.24, SE = 2.67$). However, this difference was not statistically significant, $t(23) = 1.179, p = .250$.

Finally, for participants in the low volume x expectation condition, of those who scored in the fastest one third of auditory reaction times also scored higher on the LMS-21 mindfulness measure ($M = 109.63, SE = 4.97$) than those who scored in the slowest two thirds of reaction times ($M = 107.69, SE = 3.54$). However, this difference was not statistically significant, $t(22) = .309, p = .761$.

Consequently, having higher LMS-21 scores did not significantly predict being in the top one third of fastest auditory reaction times, as measured by the Simple Auditory Reaction Time Test scores.
Mindfulness and Visual Reaction Time Correlational Analysis

Another hypothesis of this study was that there would be a statistically significant correlation between the Langer Mindfulness Scale scores (LMS-21) and the Simple Visual Reaction Time Test scores. To this end, a Spearman Correlation Analysis was conducted to determine if such a relationship existed between pretest Langer Mindfulness Scale scores and scores on the Simple Visual Reaction Time Test.

After outliers and assumptions were inspected a Spearman Correlation Analysis was conducted. There was no statistically significant correlation between LMS-21 scores and Simple Visual Reaction Time Test scores (\( p = .339 \)). Consequently, the increases or decreases in the LMS-21 scores do not significantly predict increases or decreases in the Simple Visual Reaction Time Test scores or vice versa.

In addition, a series of t-tests were run to determine if faster visual reaction times were associated with higher mindfulness scores overall and within particular conditions. In regards to our total pool of participants, of those who scored in the top one third of the fastest visual reaction times also scored higher on the LMS-21 mindfulness measure (\( M = 114.21, SE = 1.98 \)) than those who scored in the slowest two thirds of visual reaction times (\( M = 110.55, SE = 1.63 \)). However, this difference was not statistically significant, \( t(99) = 1.357, p = .178 \).

Similarly, for participants in the expectation only conditions, of those who scored in the top one third of the fastest visual reaction times also scored higher on the LMS-21 mindfulness measure (\( M = 114.22, SE = 2.43 \)) than those who scored in the slowest two
thirds of visual reaction times ($M = 107.47, SE = 4.09$). However, this difference was not statistically significant, $t(23.114) = 1.407, p = .173$.

On average, for participants in the low volume only conditions, of those who scored in the top one third of the fastest visual reaction times also scored slightly higher on the LMS-21 mindfulness measure ($M = 112.89, SE = 5.89$) than those who scored in the slowest two thirds of visual reaction times ($M = 112.65, SE = 2.63$). However, this difference was not statistically significant, $t(24) = .043, p = .845$.

Finally, for participants in the low volume x expectation condition, of those who scored in the fastest one third of visual reaction times also scored higher on the LMS-21 mindfulness measure ($M = 114.22, SE = 2.31$) than those who scored in the slowest two thirds of reaction times ($M = 107.47, SE = 4.13$). However, this difference was not statistically significant, $t(24) = 1.407, p = .173$.

Consequently, having higher LMS-21 scores did not significantly predict being in the top one third of fastest visual reaction times, as measured by the Simple Visual Reaction Time Test scores.

Comprehension

This study hypothesizes that, in regards to the podcast comprehension assessments, participants that listened to their podcast at a low volume level would outperform participants placed in conditions where they listened to their podcast at a normal volume. Conversely, it was anticipated that expectation would have no impact on podcast comprehension assessments. A factorial ANOVA was to be conducted to
compare the main effects of expectation and volume and the interaction effect between expectation and volume on podcast comprehension scores. However, a ceiling effect was observed in regards to podcast comprehension scores. A ceiling effect occurs when a large concentration of participants score within a distinct upper limit of a particular assessment (Hessling, Traxel & Schmidt, 2004). In this case, a high proportion of subjects in this study received maximum scores on the podcast comprehension assessment. Specifically, 59.6% of participants earned 100% on the podcast comprehension quizzes. As a result, the true extent to which the listening to podcasts at a low volume and expectation impacted participants ability to comprehension the podcast content cannot be determined.
Chapter IV
Discussion

By mindfully experiencing auditory stimuli it may be possible to positively influence what is traditionally viewed as fixed hearing outcomes. The hypotheses of this study explore the mind body construct, which posits that the mind and the body are inseparably bound, to the point that the mind has the power to exert great influence on one’s physiology. Thus, if mindfulness interventions can influence the manner in which the mind experiences stimuli, then perhaps through the mind-body construct, improvements to one’s physiology can be made. For clarity, this overarching hypothesis was subdivided into specific hypotheses.

Low Volume & Hearing Outcomes

One of the primary hypotheses of this study claimed that inducing the mindful component of noticing new things by listening to a podcast at a low volume would result in improvements to hearing outcomes. Specifically, it was postulated that participants who listened to their respective podcasts at a low volume would perform significantly better on posttest hearing tests when compared to participants who listen to podcasts at a normal volume. In regards to hearing posttest scores, where pretest hearing scores were used as a covariate the main effect for volume was found to be significant, $p = .015$. This indicates that those who listened to podcasts at a low volume performed better on posttest
hearing tests ($M = 70.62, SD = 6.319$) than those who listened to their podcast at a regular volume ($M = 67.66, SD = 6.721$).

Such results give further credence to the mind-body construct for they illustrate the potential of mindfulness interventions to positively impact physical functioning. Consequently, these results may indicate that thirty minutes of listening to verbal information at a low volume has the power to improve hearing under certain circumstances. Due to the limited scope of this study, it is unclear exactly why listening to podcast information at a low volume improved hearing outcomes. Perhaps such listening was able to activate the attentional system in a manner that made participants better able to concentrate on the hearing test. Maybe such listening interventions positively impacted participants’ auditory system in a way that improved their ability to hear external stimuli. Further research designed to explore the mechanisms by which hearing improved would need to be done to determine the cause of such improvement. Additionally, it is important to note that the subjects of this experiment had not been diagnosed with hearing loss prior to this experiment and thus it is unclear whether such an intervention would aid those with hearing impairments. A logical next step in research would be then to test this intervention on individuals with moderate hearing loss.

**Expectation & Hearing Outcomes**

Another hypothesis this study evaluated explored the impact of expectation on hearing ability. Specifically, this study hypothesized that participants who were placed into a condition where they were told to expect their hearing to improve would outperform participants who were placed in conditions where there was no expectation.
The main effect for expectation was significant ($p = .061$), indicating participants in expectation conditions ($M = 70.69, SD = 6.58$) outperformed participants in non-expectation conditions ($M = 67.65, SD = 6.424$) in terms of hearing tests based on a one tailed significance level of .10. This claim is further bolstered by a correlation analysis that revealed that being in an expectation group was significantly associated with better scores on hearing tests, $p = .023$. Simply put, participants that were placed in conditions where they were told to expect their hearing to improve did significantly better on hearing outcomes when compared to participants that were not told to expect their hearing to improve.

Such results also bolster the mind-body connection for the illustrate that simply believing that one’s hearing will improve may actually have the power to improve hearing outcomes. These findings give further credibility to the impact that placebos can have on health outcomes in general. They also suggest that sensory processing difficulties, like mild to moderate hearing impairment might benefit from placebo interventions where participants are told to expect that their hearing will improve.

Low Volume & Comprehension

This study postulated that the participants who listened to podcasts at a low volume would have greater comprehension of the material presented within the podcasts, when compared to individuals who listened to podcasts at regular volumes. To test this hypothesis, all participants were given a comprehension quiz, designed to assess their understanding of their chosen podcast (See Appendix 5: Post Intervention Materials: Podcast Comprehension Assessment). Unfortunately, this study was not able to determine
the extent to which listening to information at a low volume impacted comprehension. Upon analysis, a ceiling effect was discovered, with approximately 60% of all participants scoring 100% on the comprehension assessment. These results indicate that the assessment itself was not challenging enough for the participants taking it. Ceiling effects, though unfortunate are not unheard of when assessing the cognitive abilities of college educated students, especially when such students show high levels of academic proficiency, as is the case of Harvard undergraduates.

As a consequence, since a majority of participants, regardless of condition, performed perfectly on the assessment, there is not enough variance within the scores to determine if people who listened to podcasts at a low volume had superior comprehension when compared to participants who listened to podcasts at a regular volume. Thus, the impact that listening to information at a low volume has on comprehension remains an unanswered and pertinent question that deserves investigation. Future research aimed to answer this question should take care to ensure that comprehension measures are challenging enough to produce meaningful differences within participants. To that end, it might be prudent to perform a feasibility test of comprehension assessments whereby a number of individuals who could qualify for the study take the comprehension assessment so that researchers can determine whether the current comprehension assessment has been calibrated correctly.

**Low Volume & Reaction Time**

A further hypothesis of this study asserted that participants who listened to podcasts at a low volume would have faster reaction times than the participants who
listened to podcasts at a regular volume. This hypothesis went on to state that better reaction times would be seen for both auditory as well as visual reaction times, for that although the current intervention only targets the auditory system, the visual system would also be positively impacted by engaging in an intervention that induced the mindful element of noticing change.

To test these predictions the Simple Auditory Reaction Time Test and the Simple Visual Reaction Time Test from the Millisecond Test Library were administered post intervention. In terms of auditory reaction time, the Simple Auditory Reaction Time Test instructs participants to press the spacebar as soon as they hear a tone. Higher scores on the Simple Auditory Reaction Time Test indicates greater auditory reaction time.

In regards to the Simple Auditory Reaction Time Test, the main effect for volume was not significant, $p = .699$. Thus, the auditory reaction time scores of people who listened to podcasts at a low volume ($M = 258.47, SD = 38.72$) were not significantly better than the auditory reaction time scores of people who listened to podcasts at a regular volume ($M = 261.18, SD = 29.38$). This analysis indicates that listening to a podcast at a low volume for 30 minutes does not positively or negatively influence one’s auditory reaction times.

Visual reaction time was measured using the Simple Visual Reaction Time Test, whereby participants were instructed to press the spacebar as soon as they saw a circle on the computer screen. Higher scores on the Simple Visual Reaction Time Test indicate faster visual reaction times.

Similarly, in regards to the Simple Visual Reaction Time Test, the main effect for volume was not significant ($p = .147$). Therefore, there was no significant difference
between the visual reaction time scores of those who listened to podcasts at a low volume ($M = 294.38, SD = 41.90$) and the visual reaction time scores of those who listened to podcasts at a regular volume ($M = 307.91, SD = 49.64$). This indicates that listening to a podcast at a low volume for 30 minutes does not positively or negatively influence one’s visual reaction times.

It is interesting to note that a study aimed to detect the impact of making text harder to read on processing styles discovered that written information presented in a harder to read font was more likely to produce a slower processing style characterized by systematic analytical reasoning and that such reasoning was found to be conducive to error detections (Alter et al., 2007). Thus, it may be the case that making information harder to hear similarly produces a slower processing style that is more conducive to error detection. Consequently, future research could explore whether listening to auditory information at a lower volume is correlated with a slower processing style and an increased ability to detect errors.

Low Volume & Mindfulness

Another hypothesis of this study asserts that those who listen to podcasts at a low volume would exhibit greater degrees of mindfulness by way of greater post-intervention scores on the Langer Mindfulness Scale when compared to those who listened to podcasts at a regular volume.

The Langer Mindfulness Scale is a self-assessment that evaluates an individual on multiple dimensions of mindfulness including openness to new experiences, oriented to the present moment, the degree to which one is cognizant of distinctions, awareness of
multiple perspectives and sensitivity to changing contexts. Higher scores on the Langer Mindfulness Scale indicate a greater degree of mindfulness (Pirson et al., 2012).

The main effect for volume was not significant \( (p = .897) \). Thus, there was no significant difference in regards to scores on the post-intervention Langer Mindfulness Scale between those who listened to podcasts at a low volume \( (M = 111.94, SD = 11.76) \) and those who listened to podcasts at a regular volume \( (M = 112.02, SD = 12.03) \). Simply put, participants who listened to podcasts at a low volume did not score significantly better on the Langer Mindfulness Scale than those who listened to podcasts at a regular volume.

This may indicate that listening to information at a lower volume does not increase self-perceived mindfulness. This being said, it may be the case that mindfulness may increase without the individual being consciously aware of this increase in mindfulness. The Langer Mindfulness Scale is a self-assessment that relies on the individual’s accurate assessment of their own mindfulness. As such subtle changes in one’s mindfulness brought on by a recent intervention may be imperceptible by the individual and thus may not be accurately recorded by a self-assessment scale. Additionally, the pre-intervention Langer Mindfulness Scale was administered approximately 40 minutes before the post-intervention Langer Mindfulness Scale. Such an action may have primed participants to rely on the initial assessment of their own mindfulness, thus causing them to replicate their original answers on the second Langer Mindfulness Scale. Similarly, it may be the case that an individual needs time and multiple experiences to incorporate gains in mindfulness into the self-perception of their own mindfulness. Additionally, the Langer Mindfulness Scale itself asks about a person’s
mindfulness in general and consequently the time frame in which participants are asked to assess their mindfulness may not be specific enough to produce shifts in mindfulness that have taken place over a 40-minute time frame. As a result, future research may want to utilize mindfulness assessments that do not rely on self-assessment. In this way, changes in mindfulness may be able to be detected as they occur, unencumbered by the barriers that self-assessment may present.

Mindfulness & Reaction Time

Further hypotheses postulated that there would be statistically significant correlations between the pre-intervention Langer Mindfulness Scale scores and the participants’ visual reaction time, as well as the Langer Mindfulness Scale and participants’ auditory reaction time. Specifically, these hypotheses asserted that the higher one scored on the Langer Mindfulness Scale, the better one would perform on both the Simple Auditory Reaction Time Test and the Simple Visual Reaction Time Test.

As assessed by a Spearman Correlation Analysis, there was no statistically significant correlation between the Langer Mindfulness Scale scores and the Simple Auditory Reaction Time Test scores \( p = .251 \). Consequently, the Langer Mindfulness Scale did not significantly predict higher or lower scores on the Simple Auditory Reaction Time Test. This indicates that a greater degree of one’s perceived mindfulness did not predict faster auditory reaction times.

The relationship between visual reaction time and mindfulness was also assessed through a Spearman Correlation Analysis. Here, it was determined that there was no statistically significant correlation between a participant’s score on the Langer
Mindfulness Scale and scores on the Simple Visual Reaction Time Test, \( p = .339 \). Consequently, higher or lower scores on the Langer Mindfulness Scale did not significantly relate to higher or lower scores on the Simple Visual Reaction Time Test. This indicates that a greater degree of one’s perceived mindfulness does not necessarily correlate with faster visual reaction times.

It may be the case that a person’s general appraisal of their own mindfulness is insufficient to determine the impact mindfulness has on reaction time. For instance, just because an individual appraises their general mindfulness as being high, this does not guarantee that they are in a mindful state when they are taking a reaction time test. Additionally, it may be the case that when one engages in the mindful element of noticing change they are processing information at a slower rate in order to notice the nuances of that change.

Limitations

All experiments have limitations and this one is no exception. First, this study was conducted with undergraduate students and thus generalizability may be limited to an undergraduate student population. Secondly, participants who listened to podcasts at a low volume only experienced a single 30-minute session. It may be the case that multiple sessions of this intervention may be necessary to produce a positive impact on reaction time. In addition, due to the brief nature of this study, it is unclear whether the improvements in hearing seen within the low volume and expectation conditions are maintained over time.
Perhaps the greatest limitation of this experiment is that it was unable to
determine if listening to information at a low volume improved comprehension due to a
ceiling effect. Consequently, future research on listening to information at a low level and
comprehension should take care to create adequately challenging comprehension
assessments that are calibrated to the participants intellectual capabilities.
Appendix 1.

Recruitment Materials: SONA Advertisement

SONA Advertisement

Come and listen to a 30-minute podcast of your choosing - choose from 4 podcast offerings – while helping us learn more about how individuals uniquely process information.
Appendix 2.

Informed Consent

Study Title: Individual Differences in Information Processing
Researcher: Katherine Bercovitz, Karyn Gunnet-Shoval and Ellen Langer

**Participation is voluntary**

It is your choice whether or not to participate in this research. If you choose to participate, you may change your mind and leave the study at any time. Refusal to participate or stopping your participation will involve no penalty or loss of benefits to which you are otherwise entitled.

**What is the purpose of this research?**

The purpose of this study is to further our understanding of memory and processing of information.

**How long will I take part in this research?**

Your participation will involve one approximately one 90-minute study session.

**What can I expect if I take part in this research?**

You can expect to spend 90 minutes completing assessments and listening to a podcast of your choosing. As part of the assessment process, you will need to download a free app to your Smartphone, which we will help you do. This app will require that you create an account with your name, email and password of your choosing. The company who developed the assessment will have access to your data.

**What are the risks and possible discomforts?**

If you choose to participate, we do not anticipate risk beyond that which is minimal. Minimal psychological discomfort may occur, for example, as a result of completing self-administered assessments. Further, we provide contact information in this Informed Consent should any concerns, at all, arise.

**Possible benefits of being in this research study**
We cannot promise any benefits to you or others from your taking part in this research. However, possible benefits include learning new information from the podcast to which you are exposed.

**Will I be compensated for participating in this research?**

You will receive study credit for participating in this research.

**If I take part in this research, how will my privacy be protected?**

**What happens to the information you collect?**

The data we collect will be stored in a locked filing cabinet and will be destroyed after five years. Digital copies of these documents may be kept on a password-protected file on the PI’s computer, however. All data will be published in aggregate.

The information with your name on it will be analyzed by the researcher(s) and may be reviewed by people checking to see that the research is done properly.

**If I have any questions, concerns or complaints about this research study, whom can I talk to?**

The researchers for this study are Katherine Bercovitz and Karyn Gunnet-Shoval who can be reached at 646-330-1036, 33 Kirkland Avenue, William James Hall, 13th Floor, Cambridge, MA and gunnetshoval@fas.harvard.edu. The faculty sponsor is Ellen Langer who can be reached at 617-495-3860, 1330 William James Hall and langer@wjh.harvard.edu.

- If you have questions, concerns, or complaints,
- If you would like to talk to the research team,
- If you think the research has harmed you, or
- If you wish to withdraw from the study.

This research has been reviewed by the Committee on the Use of Human Subjects in Research at Harvard University. They can be reached at 617-496-2847, 1414 Massachusetts Avenue, Second Floor, Cambridge, MA 02138, or cuhs@fas.harvard.edu for any of the following:

- If your questions, concerns, or complaints are not being answered by the research team,
- If you cannot reach the research team,
- If you want to talk to someone besides the research team, or
- If you have questions about your rights as a research participant.
**Statement of Consent**

I have read the information in this consent form. All my questions about the research have been answered to my satisfaction.

**SIGNATURE**

Your signature below indicates your permission to take part in this research. You will be provided with a copy of this consent form.

________________________________________________________________________

Printed name of participant
Appendix 3.

Assessment Materials: Herza App Screen Shots
Appendix 4.
Hearing Intervention Materials: Podcast Descriptions

Podcast Options

Podcast Options

Podcast: The Hidden Brain

Episode: Me Me Me

“It doesn't take a psychologist to see narcissism in our culture of selfies. But we decided to talk to one anyway. Jean Twenge is a researcher and author of the books The Narcissism Epidemic, and Generation Me.” (WNYC.org)

Podcast: Note To Self

Episode: New Year Same Old You

“New year, new you. That’s the idea, right? And 2016 in particular left a lot of people extra-eager to start fresh.

One problem. Our fitbits and apps and tracking tools all collect data on us. The slate isn’t clean - it’s full of digital permanent marker.

In an ideal world, all that information helps us become better people. More fit, healthier, rested, hydrated. And for some people, those stats are the motivational key to a better life. But what happens when the data just sabotages you? For some of us, data just isn’t the magic bullet for optimizing our quantified selves.

So instead of resolving to track every calorie, minute slept, and stair climbed, how about this: be gentle with yourself. This repeat episode can help” (WNYC.org).

Podcast: Radiolab

Episode: Lose Lose
“No matter what sport you play, the object of the game is to win. And that’s hard enough to do. But we found a match where four top athletes had to do the opposite in one of the most high profile matches of their careers. Thanks to a quirk in the tournament rules, their best shot at winning was … to lose.

This episode, we scrutinize the most paradoxical and upside down badminton match of all time, a match that dumbfounded spectators, officials, and even the players themselves. And it got us to wondering … what would sports look like if everyone played to lose?” (radiolab.org)

**Podcast: Planet Money**

**Episodes: The man who sued Iran and won**

“Steve Flatow's daughter, twenty-year-old Alisa Flatow, was studying abroad in Israel. One day she was on a bus in the Gaza Strip, and a suicide bomber blew the bus up. Alisa died in the attack.

The bomber was part of a group called Palestinian Islamic Jihad, which the U.S. State Department believed was funded by Iran. Flatow decided to sue Iran for monetary damages. But under the Foreign Sovereign Immunities Act, U.S. citizens couldn't sue countries.

That didn't stop Flatow. He called up Steve Perles, an international reparations lawyer. The two knocked on hundreds of doors on Capitol Hill, pitching the idea that if Flatow won his suit, and won it big, maybe they could make it too expensive for Iran to sponsor terror groups.

It worked. And in 1996, President Bill Clinton changed the law to say that an Americans could sue certain countries in terrorism cases.

So they sued.

Today on the show, hear how Steve Flatow's quest for justice put him up against both Iran and his own government—and how he shook up assumptions about international diplomacy” (NPR.org).
Appendix 5.

Post Intervention Materials: Podcast Comprehension Assessment

Podcast: The Hidden Brain

Episode: Me Me Me

1. Compared to Baby Boomers in the 70’s, surveys of current high school students reveal that twice as many expect to earn a professional degree after high school. In reality:
   a) Current high school students will receive fewer professional degrees than Boomers did after they completed high school
   b) The same number of current high school students will get professional degrees as Boomers did after they completed high school
   c) Current high school students will receive slightly more professional degrees than Boomers did after they completed high school
   d) Current high school students will receive twice as many professional degrees as Boomers did after they completed high school.

2. What can explain why the number of high school students who have received As has doubled over the last 30 years?
   a) Students have become more effective learners and academic performance has significantly improved
   b) The time high school students spend on homework has significantly gone up
   c) Teachers want students to feel good about themselves
   d) Higher levels of self-esteem in students has led to a reduction in test anxiety

3. Compared to previous generations, adults age 30 and older were seen to have
   a) An increase in happiness
   b) A decrease in happiness
   c) An increase in financial security
   d) A decrease in financial security

4. What attributes were increased in millennial women when compared to women of previous generations?
5. In regards to Facebook, people who score high on narcissism are more like to have what
Answers:

1) B
2) C
3) B
4) Confidence, assertiveness and narcissism
5) More Friends

Podcast: Note To Self

Episode: New Year Same Old You

1) Paul Ford says that he gained back the weight he lost because he could not manage his:
a) Depression
b) Mania
c) Anxiety
d) Anger

2) How did the 16th century weighing chair regulate what people ate?
a) The chair only allowed people to sit and eat for a short period of time
b) The chair weighed a person’s food before they ate
c) The chair lowered people to the point where they could no longer reach the table
d) The chair would break if the person reached a certain amount of weight

3) Paul Ford made his tracking app look like what
a) An old receipt book
b) An old encyclopedia
c) An old magazine
d) An old catalog

4) Natasha Shole’s research on slot machines showed that many people use this form of gambling as a way to do what?
5) What are the two categories that people who are disappointed with tracking technologies fall into?

Answer:

1) C
2) C
3) A
4) Escape themselves
5) One group doesn’t like the notion of tracking in general, the other group is dissatisfied with the way the technology currently is and wants the technology to improve

Podcast: Radiolab

Episode: Lose Lose

1) What color was the referee’s card that indicated disqualification?
   a) Yellow
   b) Red
   c) White
   d) Black

2) Which team would the winner of the match have to play?
   a) A Danish team
   b) A Chinese team
   c) A Korean team
   d) A German team

3) What spurred the head Olympic badminton referee to observe the match?
   a) Another badminton team complained that the athletes were trying to lose
   b) He heard sport casters report that the athletes were trying to lose
   c) He heard the audience’s boos
   d) The referee that was presiding over the game contacted him for help

4) Under what rule did both teams become disqualified?

5) Which team initially won the badminton match?

Answers:
1) D
2) B
3) C
4) Failing to use your best effort
5) The Korean team

**Podcast: Planet Money**

**Episodes: The man who sued Iran and won**

1) In court, what proof was presented that the Iranian government had been responsible for the death of Steve Flatos’ daughter?
   a) The Palestinian Islamic Jihad terrorist group gave Iran credit for the bombing
   b) Iran took credit for the bus booming
   c) A line item in the Iranian National Budget
   d) A newspaper interview with the Iranian president

2) When Steve Flato was given money as the result of his lawsuit, where did he initially believe that money came from?
   a) Seized Iranian property in the US
   b) American tax payers
   c) An Iranian weapons account
   d) A counter terrorism fund

3) What does the Foreign Sovereign Immunity Act say?
   a) A US citizen cannot sue a country
   b) A government that sponsors terrorism is not protected from civil suits
   c) An individual can sue a government if that government has not paid them for services already rendered.
   d) A foreign government cannot sue a US citizen

4) What reason did Steve Flato give for wanting to sue Iran?

5) What are the two reasons why Washington tried to block Steve Perlez from going after Iranian assets in the US?

**Answers:**
1) C
2) C
3) A
4) He wanted to put the Iranian government out of the terrorism business
5) Washington did not want Iran to retaliate by seizing US diplomatic property in Iran and the government uses Iranian diplomatic property as leverage in negotiations
Appendix 6.

Debriefing Form

Psychology Study Debriefing

Thank you for participating! Below is some information about what we are investigating:

What was this study about? This study was concerned with the concept of disfluency. Specifically, we are interested in investigating if disfluency can improve sensory and encoding abilities. We predict that reducing the volume of a podcast will improve not only memory for the content, but also hearing ability, particularly when a participant is led to expect that they may benefit from the presentation of material at a low volume.

Disfluency, or processing information with great difficulty, is a learning and decision-making construct that has gained increased attention in recent years. Researchers have demonstrated that humans tend to prefer the cognitive antithesis of disfluency – fluency – across many types of information (Alter, 2013). Although this is not necessarily surprising, some studies suggest it may do humans and society a disservice. Specifically, disfluency has shown to elicit deeper cognitive processing (Diemand-Yauman, Oppenheimer & Vaughan, 2010) and “analytic forms of reasoning” (Alter, Oppenheimer, Epley & Eyre, 2007, p. 569) of information and yield superior results (Alter). Yet, not all authors agree with this, some suggesting no improved performance as a result of disfluency (Kuhl & Eitel, 2016) and negative correlations between disfluency and accurate processing of information (Alter, Oppenheimer & Epley, 2013). Additionally, Kuhl and Eitel (2016) explain that few disfluency studies demonstrating favorable outcomes have sustained the test of replication. Moreover, researchers’ definitive understanding of the benefits of - or lack thereof - disfluency are only nascent at this point, and active examination would be fruitful.

An often over-looked area of cognitive processing that could stand to reap the possible benefits of the research discussed above, is loss or impairment in any one of the five senses. Hearing impairment, for example, is a sensory reduction that affect various aspects of affected individuals’ lives. Studying Disfluency – Intentionally lowering the volume, rather than making it too easy for one to hear things within a healthy population will hopefully improve our understanding of the cognitive and
behavioral processes that work to strengthen auditory sensory abilities in those who have trouble with hearing.

We believe that studying Disfluency within a normal hearing population will hopefully improve our understanding of the cognitive and behavioral processes that work to strengthen auditory sensory abilities. Disfluency studies have demonstrated mixed results in recent years.

**How was the study conducted?** In our study, participants were randomly assigned to one of four conditions:

- **Condition 1 (No disfluency x Expectation):** Participants in this condition were told at study outset that it is expected that testing their hearing, especially after paying specific attention to a podcast of their interest, has been shown to produce better hearing test outcomes post podcast. They were then instructed to listen to a podcast of their choosing, on headphones, for 30 minutes.

- **Condition 2 (No Disfluency x No Expectation):** Participants in this condition were instructed to listen to a podcast of their choosing, on headphones, for 30 minutes.

- **Condition 3 (Disfluency x Expectation):** Participants in this condition were told at study outset that it is expected that artificially impairing one’s hearing could improve their ability to hear afterwards. They were then instructed to listen to a podcast of their choosing, at a very low volume, on headphones for 30 minutes.

- **Condition 4 (Disfluency vs. No Expectation):** Participants in this condition were instructed to listen to a podcast of their choosing, at a very low volume, on headphones for 30 minutes.

Participants were brought to a room at William James Hall to participate in a 90-minute study session. Participants were assessed for pre- and post- measures in the
lab in all conditions. Participants were then exposed to a podcast of their choosing and then assessed on memory and other sensory measures.

**What was the hypothesis?** Our hypothesis is that using a method of auditory reduction to induce disfluency will make it easier for them to hear and remember the podcast content immediately following the intervention.

**Did we tell you everything?** Sometimes it is important that participants in psychological studies not know everything about the study until it is over, because that knowledge could influence their responses during the study. In this study we had to keep some information from you until now. We told you we were interested in furthering our understanding of individual differences in sensory and information processing when in fact we are actually interested in studying how inducing disfluency in normal hearing individuals affects their hearing, sensory ability, and recall immediately following the intervention.

**Why is this study important?** Identifying interventions to improve hearing ability is important to daily functioning and overall health and wellbeing.
References


