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A Qualitative Examination of the Listening Effort Experience of Adults with Hearing Loss

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Abstract

A Qualitative Examination of the Listening Effort Experience of Adults with Hearing Loss

Alison Marinelli, PhD

University of Connecticut, 2017

Increased effort and fatigue are common complaints of individuals with hearing loss, however the listening effort (LE) experience from the patient perspective is not well understood. Current models note the importance of cognitive factors in LE. Research, that is largely quantitative in nature, has shown equivocal findings regarding auditory signals that may cause increased LE, technologies that may ameliorate the LE experience, and the effects of LE on sensory systems. Very limited work has explored the personal aspects of LE. As a whole, however, investigations of LE fail to define the experience from the patient’s view or offer suggestions for clinical treatment. In order to elucidate this phenomenon, a qualitative examination of LE was conducted. Nineteen adults users of hearing aids were interviewed. Transcripts of interviews were analyzed for common themes. Unique characteristics of listening effort and mediators of listening effort emerged as themes. Evidence from this study suggests a need for further research regarding factors intrinsic to the individual as mediators of listening effort.
A Qualitative Examination of the Listening Effort Experience of Adults with Hearing Loss

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A Qualitative Examination of the Listening Effort Experience of Adults with Hearing Loss

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Introduction

In the audiology clinic, patients report many consequences of hearing loss. Anecdotal reports of increased effort when listening in difficult situations, coupled with accounts of fatigue and stress indicate there are many negative aspects of the patient experience of hearing loss (Bess & Hornsby, 2016; Copithorne, 2006; Noon, 2013; Ross, 1996).

Though listening effort has presumably always been a part of the hearing loss experience, it has not necessarily been recognized or acknowledged. Today, listening effort is often classified as a subtype of mental effort that is expended in auditory activities (Pichora-Fuller et al., 2016). Mental effort contributes to the larger concept of effort, defined as “a conscious exertion of power” (Merriam-Webster, 2017). Understanding the various components of mental effort is important, because these factors may also play a role in listening effort.

Mental workload

A precursor to mental effort, is mental workload. Mental workload has been studied for decades (Cain, 2007). There have been examinations of the workload of naval radar operators and air traffic controllers (Kramer, 1995; Hillburn & Jorna, 2001), pilots (Roscoe, 1992; Mouloua, Hitt & Deaton, 2001), and drivers (Brookhuis & de Waard, 2001; Lansdown, 2001; Marquart, Cabrall & de Winter, 2015). Mental workload is a multi-faceted concept. It is often defined relative to the task, and no universal definition exists (Cain, 2007; Kramer, 1990; Moray, 1979). Early definitions were introduced at the 1977 NATO symposium on theory and management of mental workload. At that time, mental workload was defined as a process, with input variables such as the environment that the experiment is completed in and the design of the task used. Workload was also seen as influenced by internal factors such as personality, previous experience, motivation, and attention. Together, these internal and external factors, subsequently
shape the end performance, by influencing response accuracy, consistency, as well as other performance variables (Johannsen, 1979). A schematic of mental workload based off this model presented by Johannsen is shown in Figure 1. From this figure, it can be seen that these internal factors may influence operator effort.

Other authors at the conference focused on specific aspects of the mental workload model, like Rasmussen (1979), who theorized about operator characteristics. In this discussion, the perspective does not focus on the entire process of mental effort, but rather examines workload from the individual perspective. In doing so, it is possible to understand how the stress applied to an individual creates a subjectively perceived strain, which then influences the individual’s internal state, and how this aspect of workload could potentially be measured (Rasmussen, 1979). Ultimately, in light of these discussions, a consensus report specifically defined mental workload as the mental effort that an individual expends during a task relative to the total capacity that can be expended (Curry, Jex, Levison & Stassen, 1979). The report included definitions of task demands, operator behavior, mental effort, stress, and strain (see a revised schematic in Figure 2).

As such, mental workload is understood as a human-centered variable, as models of mental workload consider constraints of the individual’s cognitive system, and personal characteristics like motivation and behavior (Curry, Jex, Levison & Stassen, 1979; Hart & Staveland, 1988).

In light of attempts at measuring workload, definitions have changed slightly over time but still capture the essence of mental workload as a human-centered process. The NASA-Task Load Index (NASA-TLX) is one of the most rigorous questionnaires assessing mental workload, and is still used in experimental designs today. The authors of the NASA-TLX acknowledged
differences in definition of workload, introducing their preferred definition of workload as the price individuals are subjected to in order to maintain optimal performance (Hart & Staveland, 1988). In a chapter on workload assessment, Kramer (1990) outlines several physiologic methods that have been used to quantify mental workload. The introduction includes a definition highlighting the exchange between the individual’s characteristics and abilities and the demands of the task. In a review of physiologic and subjective measures of mental workload, O’Donnell & Eggemeier (1994) present mental workload as consisting of the precise amount of the limited capacity of an individual that is necessary to complete the task. A theme through these four (of many) definitions of mental workload is that they all allude to a process that is governed by limited capacity. This limited capacity nature of mental workload suggested even in early definitions (Curry, Jex, Levison, & Stassen, 1979) has remained a constant through various iterations of the mental workload definition.

**Mental effort**

Throughout discussions on mental workload, mental effort is mentioned as a specific component of the overall mental workload process (Curry, Jex, Levison & Stassen, 1979). When task demands increase, an individual responds by mobilizing extra cognitive energy to maintain performance (Gaillard, 2001). This mobilization of extra energy is known as mental effort. However, the individual’s perceived challenges of the task, the individual’s self-efficacy in completing the task, and the cognitive processing involved with the task can influence the experience of effort (Kirschner & Kirschner, 2012).
Figure 1: A schematic of mental workload based off the model presented by Johannsen. (1979).
Figure 2: A schematic of mental workload based off of Curry, Jex, Levison & Stassen. (1979).
Cognitive components of mental effort.

Mental effort has been studied extensively across many fields. As there are mediating factors of mental workload, several cognitive processes have been identified as mediating factors of mental effort. These include attention, working memory, and motivation. Although theories of these processes are still undergoing revision, a conceptual understanding is important in order to make sense of the mental effort experience.

Cognitive components of mental effort are resource limited processes.

Clearly, attention, working memory and motivation are cognitive components involved in mental effort, but it is important to recognize these resources have a finite limit at which performance plateaus. For example, attention cannot be sustained indefinitely, working memory cannot hold an unlimited amount of units, and motivation cannot persevere forever. After a critical overload point in these systems, performance gradually degrades (Kramer, 1990; Norman & Bobrow, 1975). If several tasks use the same resource, they divide the available resources. The output of a task depends on available resource (Kahneman, 1973; Norman & Bobrow, 1975) and increase in processing resources will yield a simultaneous increase in performance (Norman & Bobrow, 1975). These limitations of performance are referred to as resource limited processing (Kramer, 1990; Norman & Bobrow, 1975; Navon & Gopher, 1979). The limitations of attention, working memory, and motivation can be measured through performance resource functions, which examine operational details of the task such as the amount of resources and average contribution of said resources to the performance (Norman & Bobrow, 1975; Navon & Gopher, 1979). These constraints are important to consider when discussing the various cognitive components of mental effort, because they limit the amount of mental effort processing that can be completed.
Attention.

Pillsbury (1908) argued that attention is central to every aspect of human existence, which made for many definitions for a single process. From this point, early theories of attention were derived from information system theories. Shannon and Weaver (1949) introduced a model of communication theory, which postulated that information travels from a source to a transmitter to a receiver before it reaches the desired destination. These authors were careful to define terms such as communication, information, and the capacity of a communication channel. In mathematically defining the terms of channel capacity, it became apparent that any realistic communication channel contains noise, which is indicative of a finite capacity to communicate the message.

Broadbent (1958) applied the terms of communication theory to the concept of attention. As he presented research from early dichotic listening studies, Broadbent argued auditory attention was limited. His model of attention became known as the filter model of attention, with sensory information being temporarily kept in the short-term store with selectively filtered units moving into a limited capacity channel to be processed and brought to awareness, only then moving toward an output. Broadbent’s model proved to be overly simplistic, as research using dichotic stimuli showed that subjects reacted to their own name in a supposedly unattended channel (Moray, 1959) and can follow a story from ear to ear (Triesman, 1960). These experiments demonstrated that irrelevant information is attenuated but accessible, rather than suppressed after a filtering process.

Kahneman (1973) proposed a capacity theory of attention. Kahneman suggested that attentional mechanisms are flexible, and can concentrate on more than one stimulus at a time. Within this model, assumptions are made that total human capacity for attention is limited, but it
can be allocated among concurrent activities. The arousal system varies the level of attentional capacity—when arousal is low, attentional capacity is also low, but when arousal is high, attentional capacity is also high (Kahneman, 1973). The amount of available attentional capacity moderates the experience of effort.

**Working memory.**

There are several models of working memory, and many of these models coexist. At the 1997 Models of Working Memory symposium, scholars worked toward a better understanding of working memory (Miyake & Shah, 1997). Baddeley (2007) argued for a multicomponent approach to working memory. In his proposed model, a central executive functions as an attentional control system, the phonological loop handles phonological memories and articulatory rehearsal, the visuospatial sketchpad controls visual and spatial information, and an episodic buffer merges each subsystem with long-term memory. This model of working memory is popular and often cited in discussions of working memory. However, it is not the only model of working memory available.

Miller (1956) introduced a concept of limits to working memory. He proposed that seven is the number of units that can be immediately recalled, the number of digits that can be reported after a single glance, as well as the number of categories an individual will group individual items into.

In 1988, Cowan introduced a theory of working memory built on Miller’s argument, and advanced the capacity limit of working memory. This theory suggested the information processing system occurs over time, with the incoming stimulus entering the focus of attention and activating a short-term memory store. If associations from the incoming stimulus connect to previous memories, the long-term memory store is activated. Similar to Baddeley’s model,
Cowan (2005) suggested that a central executive directs attention and controls voluntary processing. The difference between the two models of working memory is that Cowan attempts to be exhaustive, but vague, whereas Baddeley attempts to be detailed, even if not complete. In the attempt to be exhaustive, Cowan (2005) emphasized that an important mechanism of working memory is the capacity limit of attentional focus. Cowan stipulated that based on recent research, the number of chunks a human can retain in short-term memory is not as large as Miller’s stipulation of seven plus or minus two, concluding that short-term memory actually has a limited attentional focus of 4 chunks of information (Cowan, 2000).

In summary, working memory is similar to attention, in that it has a limited capacity. However, working memory is a highly individualized cognitive process and there are likely individual differences in working memory.

**Motivation.**

Motivation has long been investigated. Studies of human behavior have shown patterns of attaining pleasure and avoiding pain, which has led to the understanding of incentives. Humans are motivated when an action has a consequence, and the anticipation of the consequence drives behavior (Burns, 2003).

From the biological perspective, certain human behaviors have evolved because they were beneficial to the survival of a species. Instinct remains an important component of human motivation, though the evolutionary reasons behind the behavior may have changed (Burns, 2003). Moreover, there are several physiological mechanisms in the human body that can contribute to an individual’s motivation. Stellar (1954) argued the amount of motivated behavior is directly related to the amount of activation in excitatory regions of the hypothalamus. Valenstein and colleagues (1970) acknowledged the role of the hypothalamus, but argued
additional mechanisms are necessary to motivation. They suggest that electrical stimulation in the hypothalamus activates an instinctual hierarchy of behaviors, and the response that is seen is the one that has the greatest need.

Combining understandings of behavior and biology leads to the behavioral neuroscience perspective, which gives unique insights into motivation. This perspective argued cognitive mechanisms underlie every motor movement of the body. Each motor action is performed with the express purpose of survival. The central motive states of the brain are moderated via dopamine, a chemical neurotransmitter that provides feedback regarding actions that are particularly beneficial for evolutionary survival (Shulkin, 2008).

Still, outside the realms of behavior and biology, there are other components of human motivation. Social interactions can influence motivation. Likewise, internal goals can motivate individuals to achieve in social evaluation contexts (Atkinson, 1964; Burns, 2003). Thus, the impetus behind human behavior originates from behavioral, biologic, as well as cognitive sources.

**Physiological ramifications of mental effort.**

Cognitive factors are not the only moderators involved in the mental effort process, as there are physiological processes occurring the body that may affect the experience as well. The arousal system plays a large role in moderating the mental effort experience. While both the brain and the body influence mental effort, it is a reciprocal relationship, as the mental effort process has a direct impact on the stress processes, and the body can impact the mental effort process as well.
**Arousal.**

Arousal is the bodily state of reactivity, and levels of arousal range from sleep to excitation (Coull, 1998; Duffy, 1957; Thayer, 1991). In a classic experiment, Yerkes and Dodson (1908) trained mice to perform appropriate responses to a stimulus. These authors observed that mice did not perform the desired behavior with stimuli that were too weak or too strong. Instead, for mice to perform a desired behavior, stimuli needed to be in the intermediate range. Essentially, too little arousal yields poor performance, a medium amount of arousal yields optimal performance, but excess arousal also yields poor performance. This observation later became known as the Yerkes-Dodson law of arousal.

Arousal is linked to the reticular activating system, beginning in the upper brainstem reticular core and ascending through synaptic projections to the thalamus, moderating excitability in the cerebral cortex (Steriade, 1996). Tasks involving attention and alertness show neuronal activity in the midbrain reticular formation and thalamic intralaminar nucelei (Kinomura, Larsson, Gulyás & Roland, 1996). The neurotransmitters of this pathway have been identified as acetylcholine and glutamate (Steriade, 1996).

Arousal can be measured physiologically, via skin conductance, muscle tension, the electroencephalogram, heart rate, and respiration (Coull, 1998; Duffy, 1957; Kinomura, et al., 1996). Levels of arousal naturally vary over the day, as diurnal changes in cortisol can affect the system. Arousal levels are also affected by artificial sources, as they vary with task type and with the use of substances such as caffeine (Klingberg, 2009). Arousal can influence the mental effort experience. Any measurement of mental effort must take into consideration the arousal process, as even the most objective of paradigms can be influenced by patient-related factors. (Kahneman, 1972).
Stress.

Selye (1936) developed an early theory of stress that has been widely cited. After observing endocrine glands react to various negative stimuli, Selye postulated that the consistent response is due to stress. Later versions of his stress theory classified the body’s reaction to stress and subsequent adaptive processes. This research confirmed that the stress response involves hormonal responses of the endocrine system (Selye, 1955a). Selye (1955b) advocated that stress is inherently linked to disease.

The physiology of stress originates in the nervous system, which means that stress affects multiple systems in the body. One system is the autonomic nervous system, which regulates homeostasis. The autonomic nervous system consists of the sympathetic and parasympathetic nervous systems, which are responsible for keeping the body in homeostasis and adapting to stressors. The sympathetic nervous system drives energy expenditure, and catecholamines such as epinephrine and norepinephrine prepare the body for movement. Once these catecholamines enter the bloodstream, a variety of systems are affected. For example, heart rate increases, muscles dilate blood streams to muscles that will need oxygenated blood and constrict blood flow to areas that will not, pupils widen, bronchii expand, and the digestive system reduces activity (Hamill, 1996; Seaward, 2006). Acetylcholine drives the parasympathetic nervous system, which often creates an antagonist reaction to the sympathetic nervous system (Hamill, 1996; Seaward, 2006). The endocrine system also contributes to the stress response by generating hormones that regulate metabolic functioning (Seaward, 2006).

The hypothalamic-pituitary-adrenal (HPA) axis is a biochemical pathway highly involved in stress processes. This axis begins in the anterior hypothalamus with the release of corticotropin, which affects the pituitary gland. This gland also releases corticotropin and
stimulates the adrenal cortex. In turn, the adrenal gland releases increased amounts of cortisol and aldosterone (Seaward, 2006).

Other parts of the body, such as the reticular activating and limbic systems as well as the neocortex, also play roles in moderating stress. However, measurement of stress largely depends on responses from the autonomic nervous and endocrine system and their interactions in the HPA axis (Kramer, 1990).

Stress and mental effort.

Increased mental effort is often associated with increased levels of stress responses (Scerbo, 2001). Furthermore, it is known that stress degrades performance on mental effort tasks (Hockey, 1983). This reciprocal relationship has been a focus of interest for human behaviorists. As shown in Figure 3, stress processes are also a similar three-fold process to mental workload, with input stressors influencing a person’s perceptions and activating adaptive compensatory processes in order to meet goals and manage the output performance (Hancock, 1986).

Later versions of this model consider the individual’s psychological and physiological capabilities in order to understand performance outcomes, as shown in Figure 4 (Hancock & Warm, 1989). Breakdowns in performance may occur when a task exceeds the individual psychological and physiological capabilities. This demonstrates that the pressure to maintain high levels of mental effort are sufficient to produce a stress response (Hancock & Warm, 1989). Ultimately, individuals expending high amounts of mental effort are susceptible to high levels of stress.

It is well known that chronic stress has many negative effects on health. For instance, repeated episodes of stress decrease memory capabilities by weakening neural connections in the hippocampus (McEwen, 2002). However there are also direct links between stress and fatigue.
There are other reasons to avoid stress, besides the negative consequences of fatigue. The effort an individual expends may also be influenced by the stress that an individual experiences (Kahneman, 1973). This suggests that even the most objective of paradigms are influenced by patient related factors.

**Fatigue.**

There is no universally accepted definition of fatigue (DeLuca, 2006). Objective research has demonstrated that prolonged periods of mental effort can result in mental fatigue (Boksem, Meijman, & Lorist, 2005; Boksem, Meijman, & Lorist, 2006; Boksem & Tops, 2008; Lorist, Boksem & Ridderinkhof, 2005; Kramer, 1990; Kramer, 1995; Marcora, Staiano, & Manning, 2009; O'Donnell & Eggemeier, 1986). Prolonged periods of mental fatigue can also limit physical performance (Marcora, Staiano, Manning, 2009). Fatigue can be measured objectively via physical performance, or indirectly as a perceived state of mental or physical stamina. (DeLuca, 2006)

**Mental effort, stress, and fatigue.**

Gaillard (2006) presents a framework in which mental load, stress and fatigue are separate biobehavioral states that refer to similar phenomena, but have distinct mechanisms and outcomes. These states are highly influenced by psychosocial factors and personal characteristics and these processes are important to consider when discussing mental workload, because psychological and physiological can influence measurements of stress. In sum, there is an interrelationship between these factors, arousal, stress and fatigue, which all have effects on mental effort.
Figure 3: A schematic based on Hancock’s model of stress. (Hancock, 1986)
Figure 4: Schematic adapted from Hancock and Warm’s “Dynamic model of stress and sustained attention” (Hancock & Warm, 1989)
Measurement of mental effort and workload

Studies on mental effort have employed a variety of research paradigms in an attempt to understand the underlying cause and to document its effects. As measures of mental workload and effort likely measure similar constructs, they are both used to document the phenomena. Moray argued mental workload can be measured in two ways. The first method is to examine error and latency scores in relation to workload. If more errors or longer latencies occur, the task is deemed more effortful. The second method is based off of Kahneman’s (1978) theories of effort, referring to the model of limited capacity system, and the related subjective feelings of stress and strain (Moray, 1979). Both methods are still utilized in the measurement of the mental effort expenditures. A number of other measures have since been developed to assess the concept of mental effort including subjective, task dependent, dual-task, and physiologic measures.

Subjective measures of mental effort.

Subjective measures of mental effort and workload ask individuals to reflect and rate various aspects of the experience (O’Donnell & Eggemeier, 1994). Hart & Staveland (1988) argue that because subjective methodologies include the personal impact of an individual, these measures most closely approximate mental workload. The personal assessment of mental workload will include many factors not assessed in other methodologies. However, translating memories, which may be inaccurately recalled, into reliable and repeatable measures has been a challenge. Nevertheless, subjective measures are often used in measures of mental effort.

Rating Scales.

Rating scales are a common option for a subjective approach to examining mental effort (O’Donnell & Eggemeier, 1994). Usually used as a numerical visual analog scale, with one endpoint signifying a value, and the other endpoint signifying the opposite value, participants are
A unidimensional rating scale commonly used in the assessment of workload is the Modified Cooper-Harper Scale (MCH) (Wierwille & Casali, 1983). This scale is based on the pre-existing Cooper-Harper Aircraft Handling Characteristics scale (Cooper & Harper, 1969), which was designed to measure pilot’s workload. A decision tree is used to assess various aspects of task demand, accuracy, and operations. The MCH scale is a more general unidimensional 10 point rating scale, which uses a decision tree to reach the end rating, and is a global estimation of cognitive workload. Comparison studies have found the MCH takes a moderate amount of training to understand and time to complete, which makes it less favorable than other subjective measures of workload (Hill, Iavecchia, Byers, Bittner, Zaklad, Christ, 1992).

The National Aeronautics and Space Administration Task Load Index (NASA-TLX) is a questionnaire examining perceived workload across several domains. Designed to provide a reliable and repeatable summary of workload performance between and within subjects, this test has 10 standardized bipolar rating scales. Subscales composite into larger scales for three types of demand (mental, physical and temporal), as well as for operator opinions of workload (performance, effort, and frustration) (Hart & Staveland, 1988). Factor analysis reveals that the NASA-TLX has a high correlation with operator load, additionally, test takers preferred this test over three other subjective ratings of workload (Hill et al., 1992).

**Objective measures of mental effort.**

**Task-dependent measures.**

Task dependent measures of mental effort measure performance on a specific task in order to deduce mental effort experienced. These measures are sometimes scored unidimensionally, with higher scores indicating better performance. They can also be scored by
condition, with performance in one condition being scored relative to a performance in another condition, for instance: performance in quiet versus noisy environments.

**Dual task methodology.**

Dual task methodology is one objective measure that is used to study listening effort. This methodology operates on the cognitive principle of attention allocation of a limited capacity system (Kahneman, 1973) and presumes that as attention is allocated to a primary task, performance on a secondary task will decrease. It is inferred that the decrement in performance on the secondary task is the reflection of an increase in effortful cognitive processing (McGarrigle et al., 2014). For a dual task, a participant may be asked to listen to sentences, and press a button whenever they see a visual probe. In this example, the primary task is sentence recognition, and the secondary task is a visual probe.

The primary and secondary tasks may use the same sensory modality, or use a cross-modal design. For instance, in the same sensory modality, the primary task may consist of word recognition, the secondary task may utilize auditory memory to recall the last five words. Primary and secondary methodologies will be modified to an experiment’s aims.

**Physiologic measures.**

Physiologic measures of mental effort tap into the physical changes that occur in the individual undergoing mental effort. These physical responses are generally caused by the autonomic nervous system adapting to a signal in the environment. Benefits of physiological measures include ease of obtaining measurements, and providing reliable measurements of changes to physiological processing during baseline, during performance and after performance. Furthermore, these measures offer a unique perspective on various body systems during mental workload (Kramer, 1990).
Physiologic measures of mental effort include fMRI, electrophysiology, pupillometry, electrodermal measures, and cortisol measures.

*Functional magnetic resonance imaging (fMRI).*

fMRI with blood oxygenation level dependence is a method of examining mental and physical effort. This technique can localize neuronal activity by measuring oxygenated blood flow (Pike, 2011). fMRI investigations of mental effort reveals a common motivational system underpinning both mental and physical effort in ventral striatum of the basal ganglia (Schmidt, Lebreton, Clery-Martin, Pessiglione, 2012).

*Electrophysiology.*

Electrophysiology is often used in explorations of mental effort, as it assesses scalp recordings of the brain’s voltage oscillations. These voltages vary before and during mental workload, and provide a time-locked signal of brain activity. There are various event-related brain potentials (ERP) measures that can index mental effort, and several have documented changes in mental effort (Kramer, 1990; O’Donnell & Eggemeier, 1994).

Electrophysiological measures of listening effort have demonstrated specific changes in response to tasks of mental effort. Using an oddball paradigm during baseline, high, and low effort conditions, the N1 and N2 components were found to be sensitive to increases in difficulty. The mismatch negativity component was also sensitive to workload; however, likely represents an independent source contributing to the workload (Kramer, Trejo & Humphrey, 1995). More recent research using the same oddball paradigm, demonstrates the P3 and the late positive potential (LPP) are most sensitive to changes in task difficulty (Miller, Rietschel, McDonald & Hatfield, 2011).
Pupillometry.

In investigations of mental effort, pupillometry is used to document the body’s natural pupil response to stressors in the environment. When emotional processing occurs, the sympathetic system stimulates radial dilator muscles of the pupil, which increases pupil size. As emotional processing terminates, the sympathetic system is deactivated and the radial dilator muscle relaxes which decreases the diameter. The parasympathetic system operates as an antagonist system to the sympathetic system. When this system is activated, the oculomotor nucleus is stimulated, and the iris’s sphincter muscles actively constrict, whereas inhibition of the parasympathetic system can produce significant dilation (Granholm & Steinhauer, 2004). Measuring the various pupillary responses reliably indexes the extent of nervous system processing allocated to a particular task. Pupillometric results of mental effort tasks have shown consistently increased pupil diameters. These measures are especially valuable when rapid changes in mental workload need to be indexed (Marquart et al., 2015).

Skin conductance.

Skin conductance is physiologic response that has been used in measuring mental effort. Skin conductance assesses the moisture of the eccrine sweat glands of the palms to make inferences about the activation of the parasympathetic and sympathetic arousal activity (McGarrigle et al., 2014). Measures of mental effort using skin conductance demonstrate consistent responses in conditions with increased mental effort (Jacobs, Friedman, Parker, Tofler, Jimenez, Muller, Benson, and Stone, 1994).

Cortisol.

Examination of cortisol levels is another objective physiologic response that has been used in measuring mental effort. Cortisol measurements assess stress hormones (cortisol and
chromogranin A (CgA)) found in saliva, which are secreted in response to sympathetic activation of the neuroendocrine system (Kramer et al., 2016). Studies of cortisol and mental effort demonstrate increases in cortisol during situations of high mental stress (Peters, Godaert, Ballieux, van Vliet, Willemsen, Sweep, Heijnen, 1998).

Heart rate variability (HRV).

Examination of heart rate is another objective physiologic response that has been used in measuring mental effort and listening effort. Measurement of the heart rate and its variability is used because the autonomic nervous system (ANS) responds to environmental conditions and modifies cardiovascular performance appropriately. Studies of heart rate show that under high mental workload heart rate are sensitive to differences in baseline and task workloads, but not particularly sensitive to changes in workload between tasks (Jorna, 1992; Roscoe, 1992). However, heart rate variability measures are more beneficial as in indicating changes of mental workload (Roscoe, 1992).

Listening effort: A specific type of Mental Effort

Listening effort is considered to be a specific type of mental effort, where the task is listening. The term listening effort is currently under investigation in audiology because of the impact that it has on patients with hearing loss.

Early work on listening effort.

Though listening effort shares some of the same fundamental concepts of mental effort, it has not been a topic of study nearly as long. The phenomena of auditory effort as it applies to individuals with hearing loss was first specifically identified by Downs (1982) in a dual task paradigm experiment. In this study individuals with hearing loss exhibited increased reaction times in a dual task paradigm when listening in the unaided condition as opposed to the aided
condition. It was assumed that the improved reaction time in the aided condition was a result of the hearing aid reducing the listening demands of the environment (Downs, 1982). Hetu and colleagues (1988) conducted a qualitative investigation into the handicap experience of workers with occupational hearing loss. Although not specifically looking at listening effort, themes of significant fatigue, stress and anxiety after the workday emerged, indicating the presence of listening effort during the day. Feuerstein (1992) conducted research demonstrating individuals with normal hearing subjectively rated listening over a distance in the monoaural condition as the most effortful, with word recognition scores and dual task reaction times supporting this conclusion. Rakerd and colleagues (1996) found listening to speech is significantly more effortful via dual task paradigm for individuals with congenital hearing loss and presbycusis. After these early works, the topic of listening effort was not systematically studied for another 20 years.

More recently, a special interest group of the British Society of Audiology published a white paper attempting to describe the phenomena of listening effort. Referencing the Oxford English Dictionary, listening effort was defined as mental concentration needed to listen and comprehend an auditory message (McGarrigle et al., 2014). This approach proved controversial, as responses to this definition criticized it’s simplistic dictionary approach and argued for the inclusion of cognitive mechanisms behind the phenomena of listening effort (Ronnberg, Rudner & Lunner, 2014; Wingfield, 2014).

Contemporary studies of listening effort have begun to explore factors that influence the general, multi-dimensional effort experience as they specifically relate to the listening effort experience. Hence, authors have explored the effects of motivation (Picou & Ricketts, 2014), attention (Desjardins, 2016; Degeest, Kepller, & Corthals, 2015; Desjardins & Doherty, 2014;
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More recently, authors approach the concept of listening effort with a cognitive sciences lens. Often, while sometimes not explicitly defined, listening effort is indeed tied with cognition, as in the individual with hearing loss experiences listening effort due to the use of more cognitive resources in a limited capacity system (Degeest, Keppler & Corthals, 2015; Desjardins, 2016; Fraser et al., 2010; Gosselin & Gagne, 2010; Gosselin & Gagne, 2011; Hicks and Tharpe, 2002; Hornsby, 2013; Picou & Ricketts, 2014; Picou, Ricketts & Hornsby, 2011; Picou, Ricketts & Hornsby, 2013). The participants of the Eriksholm Workshop on cognitive energy supported the inclusion of a cognitive component into the definition of listening effort, adding motivation to the definition (Pichora-Fuller et al., 2016). To date, most researchers continue to explore various aspects of the listening effort experience from within the cognitive perspective.

**Current models of listening effort.**

At present, there are several working models of listening effort grounded in the cognitive domain. Ronnberg and colleagues proposed the Ease of Listening Understanding Model (ELU) in 2013. As shown in Figure 5, this model suggests that as speech is perceived by listeners it is quickly coded into a multimodal phonological representation in an episodic buffer (Ronnberg et al., 2013). Assuming that a proper lexical match is found for the incoming signal, the message is transmitted onward without difficulty. The ELU model proposes that when the signal is degraded (such as in the presence of background noise) and a lexical match cannot be made, explicit top-
down working memory processes are invoked to find a match. This theory directly relates to Baddeley’s (2007) theory of working memory as the episodic buffer is included in implicit processing as sounds are bound to phonological units to be processed. Moreover, explicit processing is completed in a general capacity system, which functions like the central executive. These deliberately invoked working memory processes are thought to be the source of effortful listening (Ronnberg et al., 2013). A benefit to this model is that it has been tested using ecologically relevant situations. While the ELU model provides an explanation of some cognitive processes likely involved in listening effort, the authors fail to include motivation, or other external influences on effort as a component in their model.

Another model to understand listening effort was developed in 2016, as participants of the Eriksholm Workshop on cognitive energy attempted to streamline information and develop a unified understanding of the rather complex phenomenon. The model that arose from this workshop is known as the Framework for Understanding Effortful Listening (FUEL). Conference attendees consolidated existing models and based the new FUEL model on Kahneman’s (1973) model of attention, as it covered the existing themes, was a seminal work on attention, and included effort into the system. Essentially, the FUEL model states that a person’s arousal level is moderated by the available capacity an individual has. The allocation policy directs available capacity towards a specific activity. As evidenced in Figure 6, there are many moderating factors upon the allocation capacity that may influence the outcomes, such as automatic attention, intentional attention, and evaluation of demands on capacity. Motivation is included in the FUEL theory of listening effort, as motivation can influence intentional attention, which may moderate the allocation of energy toward a specific task (Pichora-Fuller, 2016). It is yet too early to establish full critique of the model’s strengths and weaknesses, as forthcoming
research will expose areas that need consideration in the FUEL model of listening effort (Pichora-Fuller et al., 2016).

Both of these models have benefits, in that they help with understanding of a complex phenomenon, and can postulate reasonable causes of listening effort. However, Pichora-Fuller and colleagues have identified that the field is in a scientific dilemma regarding listening effort, because any one of these current theories is sufficient to explain listening effort (2016). It is likely that in line with scientific tradition, additional research will modify these models of listening effort. As more information can be added to the schemata and account for gaps, models will unify and expand as needed to better explain the phenomena. It is important to note that while these models are attempts to explain the listening effort phenomena, they are not definitions for listening effort. Currently, only the FUEL model provides an official definition of listening effort. The attendees of the 2016 Eriksholm workshop on hearing and cognition came to the consensus that listening effort is defined as a subtype of mental effort when the task is listening. The group successively defined mental effort as the purposeful allocation of cognitive resources in order to reach a goal (Pichora-Fuller et al, 2016). Together, with the FUEL model, these definitions may be refined as continued research leads to a better understanding of listening effort.

**Current studies examining listening effort.**

It has been recognized that listening effort is closely related to many broad processes of the human experience. These include general effort, attention, motivation, stress, anxiety, and fatigue. However, there has been a concerted effort in the study of listening effort to specifically explore the relationship between listening effort and the larger concept of fatigue. It is thought that increased listening effort may manifest in health and workplace issues (Bess & Hornsby,
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Figure 5: Schematic based off of the ELU model developed by Ronnberg et al. (2013)
Figure 6: Schematic based on the FUEL model of listening effort proposed by Pichora-Fuller et al. (2016)
Research thus far is careful to parse between physical fatigue, mental/cognitive fatigue, and general agreement contends that listening effort is a specific type of mental effort (Bess & Hornsby, 2014). Furthermore, energy and vigor are counterparts to effort, and are used to describe the capacity to do work (Hornsby, Naylor and Bess, 2016). All types of fatigue and vigor are certainly related concepts of listening effort, and part of the reason why measuring effort is so difficult.

Both listening effort and fatigue do not have gold standards of measurement; instead, a variety of objective and subjective mechanisms are employed in the systematic investigation of these constructs (McGarrigle et al., 2014; Bess & Hornsby, 2014; Picou, Gordon, & Ricketts, 2015; Hornsby, Naylor, & Bess 2016; Alhanbali et al. 2016). Through judicious use of subjective measures of fatigue, it is known that individuals with hearing loss experience decrements in vigor as well as increments in fatigue, likely due to the increased listening effort experienced (Hornsby & Kipp, 2016; Bess & Hornsby, 2016).

Exploration of listening effort often converges with questions regarding fatigue, which is due to the substantial overlap between these phenomena. Other research on listening effort focuses more specifically on the effects of listening effort in controlled laboratory situations.

**Documenting listening effort.**

A variety of methodologies have been used to document the listening effort experienced by patients with hearing loss (McGarrigle et al., 2015). Objective methods of measuring listening effort include behavioral and physiological measures. Subjective methods of measuring listening effort include self-report and questionnaires. Both methods have been used in order to
understand various aspects of the listening effort experience and are similar to those used to mental effort in general.

**Objective measures of listening effort.**

**Dual task measures.**

Dual task paradigms have been and still are widely used in the investigation of listening effort (Desjardins, 2016; Desjardins & Doherty, 2012; Desjardins & Doherty, 2014; Downs, 1982, Fraser, 2010; Gosselin & Gagne, 2010; Hornsby, 2014; Larsby, 2005, Neher, Grimm & Hohmann, 2014; Picou et al. 2013; Picou, Aspell & Ricketts, 2014; Rakerd, Seitz & Whearty, 1996). In these experimental designs, subjects are told to focus their attention on the primary task, which is often listening activity, while a secondary task is also completed. Researchers make assumptions about the effort experienced in the dual task paradigm based on performance changes on the secondary task.

Researchers have used a variety of configurations of primary and secondary tasks to measure effort. One method is to use a primary auditory task of speech recognition and a secondary task to respond to a visual probe of some sort (Downs, 1982; Hornsby, 2013; Neher, Grimm & Hohmann, 2014; Picou, Aspell & Ricketts, 2014; Picou, Ricketts & Hornsby, 2013). Some designs require sentence recognition as the primary task, and a visual tracking task that measures time on target as the secondary task (Desjardins, 2016; Desjardins & Doherty, 2012; Desjardins & Doherty, 2014).

Other types of secondary tasks can be used. Auditory primary tasks are sometimes used with an auditory memory secondary task that asks participants to recall words (Hornsby, 2013) or to repeat the last word of a sentence, and then after a period of time, recall as many of those last words as possible (Sarampalis et al., 2009). Other designs require subjects to complete word
recognition as an auditory primary task, and then categorize the word by its linguistic meaning as a linguistic secondary task (Picou, Gordon & Ricketts, 2015; Picou Moore & Ricketts, 2017). Some paradigms use an auditory speech recognition task as the primary task, and a tactile pattern recognition task as a secondary task (Fraser et al., 2010; Gosselin & Gagne, 2011). Another study using dual task paradigms uses two simultaneous secondary tasks, in which participants complete a primary auditory task of speech recognition, and two secondary visual tasks. One of these visual tasks was to visually monitor a screen for a probe, and press a button when seen; the other was an auditory memory task to recall the final five words from the primary speech recognition (Hornsby, 2013). Finally, some researchers of listening effort have flipped the paradigm to use visual memory as a primary task, and auditory recognition on the secondary task (Degeest, Keppler & Corthalls, 2015; Rakerd, Seitz & Whearty, 1996).

While there a variety of ways to construct a dual task paradigm, there have also been attempts to evaluate the methodology. Reviews of studies using dual task paradigms have demonstrated that behavioral measures suffer from imprecision and are difficult to compare results across studies (Ohlenforst, Zekveld, Jansma, Wang, Naylor, Lorens, Lunner, & Kramer, 2017). A number of studies have investigated the effects of a secondary task in the dual task paradigm, but have demonstrated different effects across studies. In one such experiment, a traditional paradigm was compared to a non-traditional dual task where participants completed a speech recognition task and an alternative secondary task of completing a driving simulation. Results demonstrated that as expected, driving performance declined significantly with the addition of a speech recognition task, but overall performance was consistent between the traditional and unconventional paradigms. In this experiment, there was no effect of changing the secondary task. (Wu, Aksan, Rizzo, Stangl, Zhang & Bentler, 2014). However, some studies
demonstrate distinct effects of changing the secondary task. In an experiment that compared participants’ reaction times to a simple visual probe and a complex visual probe, as well as reaction times to identifying the presented word’s semantic category, it was found that the semantic paradigm was more sensitive to the effects of background noise. It was argued that this effect is due to the increased processing required to not only hear the word amidst background noise, recognize and repeat it, but also to comprehend the meaning and the linguistic category it belongs to (Picou & Ricketts, 2014).

Task-dependent measures.

There are task dependent measures of listening effort, in which performance on a specific task is analyzed in order to deduce the effort experienced (Feuerstein, 1992). Typically, in these paradigms, the level of the signal to noise ratio is adjusted until the participant achieves 95% (or another criteria X) correct word recognition, and this is known as the SRT95 (or SRTx). Word recognition testing is conducted in this condition. Additionally, at times, participants are asked to repeat the last word of each sentence as well as freely recall the last several words when prompted (Lunner, Rudner, Rosenbom, Agren & Ng, 2016). Recognizing a poorly audible signal takes resources away from higher-level attention and working memory processes. As such, estimations of listening effort can be made through this type of task design.

Psychophysiological measures.

A variety of psychophysiological indices have been used to assess listening effort. In these paradigms, listening tasks are often completed while measurements of bodily functions such as pupillometry or heart rate variability are recorded. Changes in recordings relative to baseline conditions are interpreted as a change in listening effort. Studies using psychophysiological indices of listening effort have some of the highest consistency across

Additionally, attempts to compare dual-task measures with psychophysiological measures have been made. Results found comparable estimates of listening effort between psychophysiological measures of heart rate variability and traditional behavioral dual task measures (Seeman & Sims, 2015).

**Subjective measures of listening effort.**

Several studies have used rating scales and questionnaires to subjectively quantify the individual listening effort experience. It is important to note though, that subjective measures of listening effort are generally not considered to be indirect measures of cognitive processes involved in listening effort (Picou, Gordon & Ricketts, 2015). Reviews of listening effort literature have demonstrated that subjective measures do not demonstrate consistent results
across studies, possibly due to the variety of different measures and unstandardized methods (Ohlenforst, Zekveld, Jansma, Wang, Naylor, Lorens, Lunner & Kramer, 2017).

Questionnaires.

There are a number of questionnaires that are widely used in explorations of listening effort. The Speech, Spatial, and Qualities of Hearing Scale (SSQ) is a questionnaire that explores aspects of hearing, including listening effort, and it has been used to investigate the subjective listening effort of individuals with hearing loss (Gatehouse & Noble, 2004). Specifically, questions 14, 18, and 19 inquire about concentration, effort, and ease of listening. As such, it has been used in a variety of studies examining listening effort. Oftentimes, the SSQ questions have been modified to be appropriate for the particular study (Dwyer, Firszt & Reeder, 2013; Hornsby, 2013; Johnson, Xu & Cox, 2016; Picou, Ricketts & Hornsby, 2011).

The Multidimensional Fatigue Symptom Inventory (MFSI) (Smets, Garssen, Bonke, De Haes, 1995) is a questionnaire designed to quantify fatigue. The inventory covers the dimensions of general fatigue, physical fatigue, cognitive fatigue, diminished motivation and decreased activity. Based on participants responses, fatigue experience is categorized across multiple dimensions. This questionnaire has been used to make inferences about the fatigue resulting from listening effort (Hornsby, 2013).

Another questionnaire that is used during investigations of listening effort is the NASA-Task Load Index (NASA-TLX) (Hart & Staveland, 1988). Recall that this questionnaire is designed to elicit information about an individual’s workload across a variety of dimensions, including mental, physical and temporal demands, frustration, effort, and performance. This questionnaire was modified for use in an exploration of listening effort to provide a multivariate assessment of the experience (Ahlstrom, Horwitz & Dubno, 2013; Bologna, Chatterjee & Dubno,
Rating scales.

A variety of rating scales have been used in the exploration of listening effort. Many of these are not standardized and have been designed for the purpose of the investigation they were used in. Scales of zero to eight (Neher, Grimm & Hohmann, 2014) zero to ten (Picou, Moore & Ricketts, 2017; Picou, Ricketts & Hornsby, 2011) zero to one hundred (Bentler & Duve, 2000; Feuerstein, 1992), zero percent to one hundred percent (Fraser, Gagne, Alepins & Dubois, 2010) and negative three to positive three (Brons, Houben & Dreschler, 2014) have been used. Questions have been generated for the experiment at hand (Picou, Moore & Ricketts, 2017; Fraser, Gagne, Alepins & Dubois, 2010) or modified from other questionnaires such as the SSQ, the MFSI (Hornsby, 2013; Picou, Ricketts & Hornsby, 2011). Visual analog scales are often used, (Desjardins, 2016; Luts, Eneman, Wouters, Schulte, Vormann, Buechle, Dillier, Houben, Dreschler, Froehlich, Puder, Grimm, Hohmann, Leijon, Lombard, Mauler & Spriet, 2010; McAuliffe, Wilding, Rickard & O’Beirne, 2012) though verbal rating scales have also been used (Johnson, Xu & Cox, 2016).

Qualitative measures of listening effort.

Although much more limited in use, qualitative measures have been used to assess listening effort. An attempt at using qualitative methodologies to assess listening effort was conducted. Johnson, Xu & Cox (2016) asked participants to journal about their experience trialing hearing aids and diaries were analyzed using qualitative analysis.

Multiple measures used to assess listening effort.

It is important to recognize that many studies of listening effort use multiple methodologies in an attempt to assess the experience from a variety of domains (Bentler, Wu,
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Using multiple methodologies allows for the exploration between the relationship between methodologies. Currently, the relationship of subjective and objective measures of listening effort are not well understood, as conflicting results from these two measures may not be generalizable (Ohленфорст, Zekveld, Jansma, Wang, Naylor, Lorens, Lunner & Kramer, 2017; Picou, Gordon & Ricketts, 2015; Picou, Ricketts & Hornsby, 2011), which indicates these measures target different aspects of the listening effort experience (Picou, Gordon & Ricketts, 2015). Frequently, results from one methodology contradict results from another type. Additionally, results from experimental studies also differs from patient experiences. Further exploration is needed to understand why this phenomena happens.

Factors related to listening effort

Although a variety of methodologies have been used and different aspects have been addressed, factors relating to listening begin to emerge. Figure 7 provides a visual representation of the current literature documenting listening effort. Those factors will be discussed below.
Figure 7: Summary of currently explored factors related to listening effort

- **Signal Factors**
  - Reverberation
  - Background noise

- **Device Factors**
  - Aided Benefits
  - Noise Reduction
  - Directional Microphone
  - Frequency Compression

- **Personal Factors**
  - Motivation
  - Job Control

- **Cognitive Factors**
  - Attention
  - Working Memory

- **Physiological Effects**
  - Pupillometry
  - Skin Conductance
  - Cortisol Levels
  - Heart Rate Variability

Listening Effort
Signal factors.

There are a number of auditory signals that have been suggested to be effortful. Signal factors include background noise, reverberation, and informational masking.

**Background noise and reverberation.**

Noise and reverberation are known as signals that make it difficult to understand speech in, and when combined, they are even more challenging (French & Steinberg, 1947) Studies examining normal hearing adults in difficult listening situations, show difficulties with reverberant signals. Normal hearing adults need increasingly better SNRs to understand material with increasing reverberation. As signals become more reverberant, subjects must recruit additional resources to understand the signal (Neumann, Wroblewski, Hajicek & Rubinstein, 2010; Picou, Gordon & Ricketts, 2015). However, testing of adults with normal hearing shows that response times on a dual task paradigm did not differ significantly than conditions in quiet and without reverberation (Picou, Gordon & Ricketts, 2015). Finally, fMRI data of normal hearing subjects demonstrates that when speech varies in intelligibility, the brain utilizes different processes to understand it. When attended, spectrally degraded sentences were intelligible, but when not attended to, cortical processing and memory of these sentences was reduced (Wild, Yusef, Wilson, Peelle, Davis & Johnsrude, 2012).

**Informational masking.**

Informational masking is also challenging for listeners. A tonal rhythm test that was masked by speech subjectively demonstrates the difficulty of normal hearing listeners. However, behavioral thresholds did not increase, which indicates that normal hearing listeners are able to compensate despite the difficulties, likely due to an increase in listening effort (Bologna, Chaterjee & Dubno, 2013).
The location of the signal as it relates to mental workload has been also investigated. When speech and noise are spatially separated, listening is subjectively rated as less effortful (Ahlstrom, Horwitz & Dubno, 2013).

**Device factors.**

Communication with a hearing loss is impacted by a lack of information. Increases in performance require better signals (Norman & Bobrow, 1975; French & Steinberg, 1949) therefore hearing aids attempt to provide an audible signal in order to improve communication. In general, objective experimental paradigms to investigate the efficacy of hearing aid technology at reducing listening effort demonstrate mixed results (Ohlenforst, Zekveld, Jansma, Wang, Naylor, Lorens, Lunner & Kramer, 2017). Furthermore, when these objective results are compared to results from subjective methodologies, data are sometimes in conflict with one another (Picou, Gordon & Ricketts, 2015; Picou, Ricketts & Hornsby, 2011).

**Use of hearing aids.**

Researchers have attempted using objective methodologies to deduce if technology in a hearing aid assists with the listening effort and fatigue experienced. Downs (1982) using objective dual task methodology demonstrated that individuals with hearing loss experienced greater amounts of listening effort when unaided, as compared to when aided, as evidenced by increases in reaction time. Bentler & Duve (2000) conducted a retrospective analysis of various types of hearing aids examined subjective rating of listening effort, however, no significant differences in effort were found between hearing aids. Hallgren and colleagues (2005) demonstrated reduction in listening effort when wearing hearing aids and listening to speech in various types of masking noise (Hallgren, Larsby, Lyxell & Arlinger, 2005). Hornsby (2013) used dual task methodology to demonstrate that while wearing hearing aids benefits the listening
effort experience, as compared to unaided conditions, listening effort experienced with hearing aids using advanced signal processing is not significantly different than hearing aids with basic signal processing. However, subjective self-reports from this study showed mixed results as to whether patients perceived a benefit in the listening effort experience, as none of the questions regarding concentration listening effort and distractibility derived from the SSQ found a significant difference between unaided and aided conditions. Conversely, questions regarding mental fatigue and attention derived from the MFSI found a significant increase in all listening conditions (Hornsby, 2013). Thus, results from this study draw inconclusive conclusions about the listening effort experience. Instead of a dual task paradigm, Johnson and colleagues used a single blinded, repeated, crossover trial, examining objective speech understanding and a subjective rating scale of various hearing aids. This study found similar effects to Hornsby’s objective results, as results indicated that hearing aids with basic technology levels and hearing aids with premium technology both provide decrements in listening effort, but generally speaking, no major differences in technology levels is found (Johnson, Xu & Cox, 2016).

**Noise reduction technology.**

Other studies have examined the differences in specific hearing aid features such as directional microphone technology and noise reduction. Some studies show no reduction of listening effort due to noise reduction technology (Alcántara et al., 2003; Brons, Houben, & Dreschler, 2013; Desjardins & Doherty 2014; Desjardins, 2016). However, other studies did find a reduction of listening effort due to noise reduction technology (Bentler, Wu, Kettel & Hurtig, 2008; Brons, Houben & Dreschler, 2014). Different types of noise reduction algorithms have been assessed in relation to the effects of listening effort, and codebook based algorithms have been found to be the best at reducing listening effort in in non-stationary noise as compared to
minimum statistics and amplitude modulation spectrogram schemes (Harlander, Rosenkranz, Hohmann, 2012). Brons and colleagues (2012) attribute the differences in results regarding noise reduction and listening effort due to individual differences within the various studies, as opposed to an actual benefit from noise reduction technologies. Moreover, more recent research from Bentler (2015) indicates that real world environments may not noisy enough to trigger noise reduction algorithms in hearing aids. Therefore, patients may or may not experience a change in listening effort due to noise reduction depending on their environment.

**Directional microphone technology.**

Results demonstrate that directional microphone technology may provide a decrease in listening effort for patients. Results suggest that directional microphone technology decreases reaction times in some conditions, which presumably shows improved listening effort experience. (Desjardins & Doherty, 2014; Picou, Aspell & Ricketts, 2014; Picou, Moore & Ricketts, 2017). Subjective benefit of directional microphones has also been observed as well (Picou, Moore & Ricketts, 2017). This effect was seen in a controlled laboratory environment with spatially segregated sound sources, which enhance the effect seen. Wu & colleagues (2014) designed a real life driving task to assess listening effort outside of the laboratory, and found that listening effort was not affected by directional microphone technology in the outside of the laboratory. Similar to noise reduction technology, directional microphones may or may not provide a reduction in listening effort for patients, depending on the environment.

**Frequency compression technology.**

In general, the goal of frequency compression can move segments of amplified speech from region to another to move elements from an inaudible region to an audible. A single study by Kulkarni and colleagues explored the effects of frequency compression on the listening effort
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of normal hearing adults and adults with hearing loss. It was found that moderate levels of frequency compression may improve consonant recognition and reduce response time. With their algorithm, improved speech recognition and decreases in listening effort, at the most difficult signal to noise ratio they found a small but statistically significant improvement on listening effort as evidenced by recognition scores and response times (Kulkarni, Pandey, Jangamashetti, 2012). However, as this is the only study to assess frequency compression technology on listening effort, further investigation needs to be completed.

Personal factors.

There has been an effort to document personal facets of listening effort, and as such, there have been experiments focusing on this aspect of listening effort. Personal factors include for example, emotion, individual lifestyle, and personality. Personal factors that have been studied are motivation & job control.

Motivation.

As noted in the prior section, motivation can influence measures of effort. Picou & Ricketts (2014) found that an individual’s motivation may be a mediating factor in the overall listening effort experience. Subjects in the high motivation condition were told that they were to be quizzed on the material heard, and subjects in the low motivation condition were not informed. From their objective speech recognition task demonstrated differences in perceived effort in high motivation conditions and low motivation conditions. Subjective ratings of performance using questions derived from the SSQ were also used. When auditory only signals were used, the easy listening, low motivation conditions, revealed higher subjective ratings of tiredness. In more difficult listening conditions, subjective ratings showed more effort and more tiredness than in other listening conditions. When auditory visual signals were presented in the
easy listening condition, subjective measures demonstrated higher levels of listening effort and tiredness, and were more likely to utilize a controlling strategy. In more difficult listening conditions, ratings consistently demonstrated increased listening effort, tiredness, and controlling strategy. Interestingly, the authors comment that a limitation of the study was the usage of a subjective measure to investigate the relationship between motivation and listening effort, citing previous laboratory research showing weak correlations between subjective and objective measures of listening effort. Ultimately, based on objective data, these authors conclude that motivation can have an effect on subjective ratings of listening effort and tiredness (Picou & Ricketts, 2014).

**Employment.**

Early work by Hetu (1988) indicated that workers with hearing loss experienced negative consequences of hearing loss, which include fatigue, stress, anxiety, isolation, lifestyle alterations, and appearing incompetent. These can lead to communicative disengagement.

More recently, in exploring the relationship between hearing loss, listening effort, and employment, Nachtegaal and colleagues (2009) used subjective questionnaires to look at recovery at the end of the workday. Recovery is thought of as the need for rest after a stressful event. Audiometric data, fatigue and work quality questionnaires revealed that individuals with poorer hearing have significantly higher need for recovery at the end of a work day, this is interpreted to support that there is the perceived listening effort during the work day.

**Hearing handicap.**

Along with motivation, an individual’s self-concept of handicap can influence their overall listening experience. Handicap is known as the difficulties associated with the impaired bodily structure (Alhanbali, Dawes, Lloyd & Munro, 2016). Analyzing objective pure tone
averages and using subjective measures across groups has consistently determined that degree of hearing loss has little relationship to fatigue and effort (Alhanbali et al., 2016; Hornsby & Kipp, 2015), but degree of perceived handicap has a correlation to the listening effort experience (Hornsby & Kipp, 2015).

These studies are the only known attempts of examining individual factors that may mediate listening effort at this time, though it seems that other personal factors such as environment, personality, and may moderate the listening effort experience.

**Physiological effects.**

Listening effort can be impacted by other sensory systems, as visual cues can assist in understanding auditory messages. Moreover, listening effort is obviously driven by cognitive factors, but there are physiologic byproducts as well. Psychophysiological measures of listening effort measure the body’s response to a variety of stimuli, and can help explain responses during stressful conditions. These measures include several different objective methodologies. Pupillometry is widely used, but electroencephalographic, heart rate variability skin conductance measures have also been used to document the physical reaction to increased effort in difficult listening situations.

**Age.**

An individual’s age may play a role as well, as older adults have declines in brain function that may contribute to increased listening effort. It is well understood that increasing age is a significant determinant of listening effort (Degeest, Keppler & Corthals, 2015; Gosselin & Gagné, 2011). Through an extensive literature review of relevant literature, Humes and Young (2016) conclude that declines in multiple sensory systems predict declines in cognitive function.
among older adults. Though more research is needed in this area, it does suggest that older adults may have demands placed upon fewer cognitive resources.

*Hearing access.*

There have been attempts to explore the effects of unilateral and bilateral hearing on listening effort. Normal hearing participants simulated unilateral hearing loss and tested in speech in noise, compared to binaural conditions. Listening effort was subjectively rated higher in all monoaural conditions. Objective measures showed no significant differences between monoaural and binaural near conditions, though monaural far conditions fared significantly poorer (Feuerstein, 1992). The SSQ has been used to study populations with hearing loss and found that individuals with unilateral hearing are at a disadvantage communicatively, but no mode of hearing effect was found for listening effort, indicating that individuals with all ranges of hearing experience effort similarly (Dwyer, Firszt & Reeder, 2013). Finally, both participants with congenital & adult onset hearing losses experience significant difficulty as measured by performance in dual task paradigm.

*Access to visual cues.*

Studies with normal hearing individuals show mixed results of visual cues on listening effort. Dual task paradigms demonstrate that visual cues when SNR is controlled across audio only and audio-visual conditions, accuracy is higher with visual cues, and is rated as less effortful. In experiment two, SNR was averaged in order to create equal performance and results did not differ significantly. Self-report questionnaires were also used. Analysis of data from experiment one revealed that participants rated the effort required to perform the experimental task as less effortful in the auditory-visual modality as compared to the auditory only modality.
However, analysis of subjective data from experiment two revealed no significant differences across auditory-visual and auditory-only modalities. (Fraser, Gagne, Alepins & Dubois, 2010).

Results of a paired associates recall task demonstrated no effects of additional visual cues. Modified questions from the SSQ were also used, which subjectively demonstrated that the presence of visual cues did not influence listening effort, but the addition of background noise did increase listening effort (Picou, Ricketts & Hornsby, 2011).

Furthermore, a dual task condition demonstrated that while listening effort increased in noise, visual cues did not affect the listening effort experienced. Also in this experiment, it was found that low lip reading ability or working memory capabilities predict effortful integration of audio-visual information in difficult listening situations (Picou, Ricketts & Hornsby, 2011).

**Pupillometry measures.**

Pupillometric explorations of listening effort often assess subjects with normal hearing. Researchers have applied pupillometric measurements to objectively measure the underlying mechanisms of a number of tasks that induce listening effort. Research with normal hearing participants listening in difficult situations demonstrates listening to speech in noise yields a larger pupillometric response than listening to non-speech in noise (Kramer, Lorens, Coninx, Zekveld, Piotrowska & Skarzynski, 2013; Kramer, Teunissen & Zekveld, 2016).

Altering the stimulus has also shown an effect on pupillometric responses. Sentences with more background noise have been shown to increase pupil size and yield longer peak latencies for participants with normal hearing (Zekveld, Heslenfeld, Johnsrude, Versfeld & Kramer, 2014; Zekveld, Kramer & Festen, 2010). Interestingly, results of subjective rating scales were analyzed in conjunction with pupillometric data, and comparisons showed no statistically significant relationships between individual SRT, subjective rating and pupil response. This
indicates that those who subjectively rate the task as effortful tend not to have larger pupil dilation (Zekveld, Kramer & Festen, 2010).

Normal hearing subjects also show differences in pupil size during divided attention. Focusing attention on two sentences in noise yields larger pupil dilation size and later peak pupil latencies as compared to focusing attention on one target sentence in noise. These results are indicative of attentional effects during cognitive processing of speech in noise (Koelewijn, Shinn-Cunningham, Zekveld & Kramer, 2014).

Moreover, fMRI research comparing brain activation maps and pupillometric results in individuals with normal hearing has demonstrated increases pupil dilation have neural correlates in the superior temporal gyrus, which also demonstrate increased neural recruitment. These authors conclude that pupillometry results reflect increased cognitive processing (Zekveld et al., 2014).

Using spectrally degraded signals, pupillometric measures show increases in pupil dilation, which indicates increases in effort even though behavioral word recognition results were at 100% for participants with normal hearing. These findings suggest subjects with hearing loss utilizing cochlear implant technology may experience greater listening effort, even when behavioral test results are good. However, further testing with this population is needed (Winn, Edwards & Litovsky, 2015).

Research have examined the pupillometric responses of individuals with normal hearing and with hearing loss. Decreases in pupil size correlated with decreases in the difficulty of a word recognition task in noise, which the authors interpreted to mean that favorable signal to noise ratios yield less effort. Furthermore, significant correlations were found between pupil dilation and self-rated handicap scores (Kramer, Kapteyn, Festen & Kuik, 1997). In comparing
the performance of subjects with normal hearing and subjects with hearing impairments, results demonstrated decreases in pupil dilation for less effortful situations for both groups. However, subjects with hearing loss demonstrated different decreases in effort, as a smaller reduction in effort was found compared to subjects with normal hearing (Kramer, Kapteny, Festen & Kuik, 1997; Zekveld, Kramer & Festen, 2016). Older adults with hearing loss show similar trends (Kuchinsky, Ahlstrom, Vaden, Cute, Humes, Dubno & Eckert, 2013). Interesting results are seen in a 2016 study, where subjects with hearing loss have smaller pupil dilation than subjects with normal hearing, but subjective ratings show that individuals with hearing loss found the listening task to be more effortful (Kramer, Teunissen & Zekveld, 2016). Kramer and colleagues suggest that these results are due to limited attentional capacities.

**Skin conductance.**

Skin conductance reactivity responses have showed increases in difficult listening conditions (Mackersie & Calderon-Moultrie, 2011; Mackersie, MacPhee & Heldt, 2015) and have demonstrated differences between participants with normal hearing and those with hearing loss.

**Cortisol level.**

Measures of cortisol response show a trend toward higher cortisol responses in participants with hearing loss compared to participants with normal hearing, but results were not significant (Kramer, Teunissen & Zekveld, 2016). Cortisol results did not correlate well with pupillometric results or catecholamine results, which indicates the three measures capture a different dimension of cognitive load and the stress system (Kramer, Teunissen & Zekveld, 2016).
Heart rate.

Initial research on the effects of listening effort in normal hearing individuals through heart rate found an increase in electromyographic (EMG) activity, but no increase in heart rate during listening tasks. These changes in EMG activity correlated with changes in subjective ratings of mental effort, demand, perceived error, stress and frustration measures on the NASA-TLX (Mackersie & Cones, 2011). Mackersie and Calderon-Moultrie found that high-frequency electrocardiographic heart rate variability was lower for participants with hearing loss in difficult listening situations. As lower responses are consistent with greater task load/stress, it was concluded that participants faced increased stress in the difficult listening situations as compared to peers with normal hearing. (Mackersie & Calderon-Moultrie, 2015; Mackersie, MacPhee & Heldt). Interestingly, participants with hearing loss did not subjectively rate tasks as more demanding or stressful than participants with normal hearing. This finding directly contradicts objective findings in the same study. Authors suggested that the participants with hearing loss were familiar with the speech recognition task, which may have resulted in conflicting findings (Mackersie, McPhee & Heldt, 2015).

Ultimately, HRV may be a better measure of listening effort because it is sensitive to differences in task difficulty and differences in signal to noise ratio, whereas other objective physiologic measures do not show the same sensitivity to differences in signal to noise ratio (Seeman & Sims, 2015; Mackersie & Calderon-Moultrie, 2016).

Electrophysiologic measures.

Increases in theta power have been seen in electroencephalographic (EEG) data recorded during active listening. These measures reflect increased cognitive processes in the brain (Wisnieski, 2016). When subjects with normal hearing listened to sentence stimuli with lexically
predictable and unpredictable final words, examples of higher integration effort for unpredictable final words was found, as ERP data showed larger N400 waves (Obleser & Kotz, 2011). Advanced averaging techniques have been also applied to electrophysiological data. Through neurophysical modeling & time scale electroencephalographic neurodiagnostics, auditory attention can be monitored. Processed data shows increased wavelet phase synchronization stability (WPSS) at N1 and P2 for difficulty paradigms, which indicates increased endogenous processing for this condition (Strauss, Corona-Strauss, Trenado, Bernarding, Reith, Latzel & Froehlich, 2010).

Subjects with hearing loss demonstrated larger late positive potential (LPP) amplitudes during easier listening conditions as compared to normal hearing listeners, and LPP and novelty P3 amplitudes continued to increase with increase with increasing task difficulties. These measures did not correlate with behavioral speech recognition data, which suggests that electrophysiological measures do not simply echo the behavioral listening effort experience (Bertoli & Bodmer, 2014). It is likely these two measures capture a different aspect of the listening effort experience.

In analysis of WPSS with young and middle-aged normal hearing and hearing impaired subjects, results showed effects of age and hearing status. WPSS analysis of middle aged participants and of hearing-impaired participants demonstrated increases in endogenous processing (Bernarding, Strauss, Hannemann, Seidler, & Corona-Strauss, 2012). Overall, evidence from psychophysiological recordings demonstrate that the body undergoes stress during periods of listening effort, and that individuals with hearing loss are especially susceptible to listening effort.
A QUALITATIVE EXAMINATION OF THE LISTENING EFFORT EXPERIENCE OF ADULTS WITH HEARING LOSS

Justification for the present study

Researchers, clinicians, and patients alike are struggling to understand and to ameliorate the effects of listening effort. It has been suggested that a more precise definition is needed, because without it, assessments and interventions to alleviate listening effort cannot exist (Pichora-Fuller, et al., 2016). Research to date has suggested that a variety of signals may influence the listening effort experience, devices may modify the listening effort experience, personal characteristics can affect the listening effort experience and the body is affected by the listening effort experience. However, findings may not yet translate to patient experience as measured through self-assessment. Furthermore, results on different measures often conflict with one another, which may be interpreted that different underlying processes are being labeled as listening effort, or patient experience differed outside the lab. In general, a discrepancy between subjective and objective measures has long been recognized. For instance, some individuals report fatigue and effort, but experimental evidence might support little effort for a given task. This mismatch between subjective and objective results has also been acknowledged in audiology (Saunders & Forseline, 2006), and in studies of listening effort (Larsby et al., 2005; Fraser et al., 2010; Gosselin & Gagné, 2010; Zekveld, et al., 2010; Picou, Ricketts & Hornsby, 2011, Mackersie, McPhee & Heldt, 2015; Picou, Gordon & Ricketts, 2015) It may be that listening effort is defined differently for different individuals; what is effortful for one person may not be effortful for another.

Thus, it is clear that defining listening effort is important on a systemic level, but it is also important to understand the phenomena on an individual level. Adults with hearing loss may be significantly impacted by the problem of listening effort, as listening effort has daily and long-term impacts. At the moment, data addressing the individual experience of listening effort is
lacking. It is understood that there is a need for research on an individual level, as there are patients with similar hearing losses who have varying listening effort experiences. (Gosselin & Gagne, 2010; Hornsby & Kipp, 2015) It is critical to investigate individual factors of listening effort in order to develop effective management strategies for these patients.

Qualitative research is often used to examine which factors are relevant to individual patients. (Ekberg, Grenness & Hickson, 2014; Grenness, Hickson, Laplante-Levesque, Davidson, 2014; Grenness, Hickson, Laplante-Levesque, Meyer & Davidson, 2015) Semi-structured and open-ended interviews allow for a wider array of factors or themes to be explored as opposed to traditional quantitative paradigms. In order to have any statistical power, quantitative paradigms can only focus and control one, possibly two, aspects of listening effort. In interviews, many themes may be identified from an interview of a single patient, and because the factors are patient-generated, they should all be directly relevant to the individual listening effort experience. Beyond the advantage of understanding which aspects of listening effort are relevant to the individual perspective, interviews also allow for factors that have not yet been explored by quantitative paradigms to be explored. Quantitative paradigms carefully identify, isolate, and control the factors explored in a study as the study is designed. In contrast, qualitative paradigms allow for emergent themes to be explored, even when studies are initially conceptualized using a smaller set of factors and themes. Qualitative research may produce new factors that may not previously identified. Conducting patient interviews & analyzing them qualitatively will allow for an understanding of which factors of listening effort are relevant to the patient experience as well as potentially identify new factors.

Qualitative research can also be used to study the phenomena of listening effort in order to gain an appreciation for the individuals who experience listening effort. Interviews give
patients and research participants an opportunity and a voice with which to speak about their experiences with listening effort, which is lacking in the current literature. At the present, investigators drive research. Even when research is subjective, and aims to elicit the patient’s perspective, survey items (like the Speech, Spatial and Qualities of Hearing Questionnaire) are generated by investigators (Gatehouse & Noble, 2004). Because listening effort is such a highly personal experience, it is important to gather evidence from the patient perspective. This characteristic of qualitative work aligns well with the movement toward patient-centered care, with the argument being that “patient-centered clinical method as one in which the physician aims to gain an understanding of the patient as well as the disease- as opposed to an approach focusing strictly on the disease” (Levenstein, 1986). Patient centered interview treats the patient with respect as they tell their story. During the story telling, important biological and psychosocial variables of the health condition become apparent (Lipkin et al., 1984). To use interview in understanding the phenomena of listening effort would lead to an understanding of the disorder from the patient perspective, which could contribute to patient-centered care of listening effort in the clinic.

There are at least three reasons as to why qualitative, interpretive methods (specifically interview) would be beneficial for the study of listening effort. These include exploration of factors that pertain to listening effort that have not or cannot be studied using quantitative paradigms, gaining a holistic understanding of listening effort, and a patient-centered understanding of the phenomena.

These three justifications for the use of qualitative research to study listening effort have a commonality- in that they allow for the topic of listening effort to be studied as the multifaceted phenomena that it is. By accessing listening effort from the patient perspective, this
research may yield a better understanding of the many factors that moderate an individual’s experience with listening effort, and add details to the existing literature. Thus, the purpose of this project is to use qualitative research to systematically investigate the individual listening effort experiences of adults with hearing loss.
Methodology

Research on listening effort, and all things concerning understanding the phenomenon of hearing loss, is dominated by quantitative and experimental work. While this research illuminates important issues and questions, the perceptions of individuals with hearing loss, and their experiences living the phenomenon are underexamined. As stated in the previous section, the purpose of this study is to define and describe the listening effort experience, using interpretive methodology in order to gain insight from the voices of those with hearing loss.

Scholars have argued for the importance of both quantitative and qualitative approaches to research (Onwuegbuzie & Leech, 2003). Individually, they offer different perspectives with which to understand truth in data. Quantitative methodologies use objective and subjective measures to examine relationships and patterns within populations. In contrast, qualitative methodologies use interpretive work to enlighten patterns of reality and generate theory. Both methods are valuable and viable research avenues, but the choice of quantitative, qualitative or a mixed methods approach relies largely on the questions that are being asked. As stated in the previous section, this dissertation was conducted to systematically investigate individual experiences of listening effort, in order to lend a descriptive nature to quantitative data, which will aid in definition, to allow for an exploration of all factors affecting patient experience of LE, and to encourage patient-centered research of a subjective phenomena. As such, qualitative measures were used to reach these goals. This dissertation is best understood as a case study that examined the experiences of listening effort in individuals who have hearing loss. Case studies are especially good forms of research to answer explanatory questions about relationships traced over time and across individuals (Yin, 2003).
Sample

19 participants were recruited to this study. Snowball sampling was used, which is often used in interpretive work. Cases of interest were identified using networks of people with similar characteristics (Morgan, 2008). Participants were recruited using flyers placed in the University of Connecticut community and through local Hearing Loss Association of America Chapter email distribution lists. All participants over 18 years of age with hearing aids were included. Individuals who do not wear traditional hearing aids were not included. This included those who have hearing loss but do not use amplification, and those who use cochlear implants (CI), or bone anchored hearing systems (BAHA). Other individuals who were excluded were those who use bimodal technology or used unilateral hearing aids. Although these populations likely experience listening effort, the decision was to focus this study on the portion of the population that wears bilateral hearing aids, as the majority of the current literature on listening effort focuses on this population.

Participant recruitment was conducted according to maximum variation sampling (Sandelowski, 1995) in order to capture a broad range of experiences with listening effort among adults with hearing impairment. Attempts were made to add new cases to the sample until there were enough variations with regards to the major areas of the listening experience enumerated in the literature review. These include age, gender, hearing handicap status.

Data collection

Four modes of data collection were used: an intake form, an audiogram, the Hearing Handicap Inventory (Ventry & Weinstein, 1982; Newman, Weinstein, Jacobsen & Hug, 1991)
and an interview. Once a participant agreed to take part in the study, an appointment for two to three hours was scheduled either at the University of Connecticut or a mutually convenient location.

**Consent.**

The first step of the appointment consisted of obtaining consent from the subject through a process cleared by the University of Connecticut’s Institutional Review Board, protocol H16-172 (see Appendix A for the consent form and approved procedure). All survey and audiometric information was collected without identifying information and use a code in place of identifying information. Following signed consent to the procedures, the appointment commenced.

**Confidentiality.**

All participant data was logged using a participant identifier code which was be derived from three digit code that reflects how many people were enrolled in this study. Researchers kept all study records, including any codes to data locked in a secure location. Video recording of the interview was collected on an iPad, and immediately downloaded to a secure computer in the Aural Rehabilitation Laboratory, then deleted from the iPad. Transcription & data analysis utilized the same code. All work with data was completed by members of the research team. Participant names were not entered into the software. If mentioned in the interview (e.g. as part of a retelling of the story), participant names were replaced with the participant code in order to maintain as much confidentiality as possible.
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**Intake.**

Participants completed a short intake questionnaire based off of the work of Laplante-Levesque and colleagues (2010). Questions regarding age, gender, work status, living situation, perceived degree of hearing loss & satisfaction with hearing aids were asked.

**Assessment of hearing and hearing handicap.**

Participants were asked to provide a copy of a recent hearing test completed within one year of the study. If they did not have a recent assessment, they completed an unaided hearing screening with a portable audiometer.

All participants also completed the Hearing Handicap Inventory, either the adult version, or the elderly version- whichever was more appropriate for their age (Ventry & Weinstein, 1982; Newman, Weinstein, Jacobsen & Hug, 1991). As it has been shown that perceived hearing difficulties can influence subjective ratings of fatigue, it was pertinent to assess the audiometric and perceived hearing difficulties of the participants (Hornsby & Kipp, 2015). Both the audiometric and subjective measures were used for categorization purposes during data collection, which enlightened responses from the interview phase of the study.

**Interview.**

Participants then took part in a semi-structured interview. Semi-structured interviews asked general open-ended probes that invited the interviewee to describe and define their personal experiences in a conversational manner (Fylan, 2005). Interviews are appropriate in studies designed to gather comparable data across cases, but also provide opportunities for participants to express their perspective and subjective experience. The interview was based on the study’s conceptual framing, which drew heavily on extant literature. Factors that mediate the
listening experience include: cognitive factors, bodily factors, device factors and personal factors. This interview’s protocol was developed based off these themes, and revised through pilot testing with a smaller sample of volunteers before data collection began. The interview topics covered listening experience and targeted these content areas related to issues of listening effort. The interview began with a prompt asking participants to tell the interviewer a little bit about themselves and their hearing loss. Once the participants felt they had shared a sufficient introduction, a prompt outlining the project’s aims of exploring listening effort (which was defined as “having to do a lot of work to hear & listen”) was delivered. Participants were then asked if they had this experience, and, if needed, prompted to share an example. Follow-up questions dissected details and mediating factors of the listening effort experience. All questions were discussed with a researcher experienced in qualitative methods, which advised how best to phrase inquiries to elicit data-rich responses. Questions were also subjected to pilot testing with a 59-year-old male with hearing loss. Those questions that were successful in eliciting responses were used, and questions that were less successful were eliminated or revised as necessary. See Appendix B for a list of interview questions. While each interview covered all questions, the ordering of the questions varied somewhat as the researcher followed the interviewee’s lead. Every prompt was posed, and new questions were not asked until participants felt they no longer had any other relevant comments. The interview ended with a prompt about how participants were encouraged to email or phone if they thought of other things that were related to the topics that were discussed in the interview. The participants were given a brief overview of the process of data analysis, and told that if they had indicated they were interested, they may be contacted again to participate in a second phase of the study that verified results.
Each appointment lasted no longer than 2 hours, although the appointment length depended largely on the length of the interview. Interviews ran from 15 minutes 47 seconds to 1 hour, 59 minutes and 50 seconds. Consent and all other procedures took approximately 15 to 30 minutes. All interviews were recorded on an iPad and later transcribed by the researcher, other doctoral students, or research assistants in the aural rehabilitation lab.

**Data Analysis**

After the interview, each intake form was recorded into a master file. Then each Hearing Handicap Inventory was scored by sub-scale (social & emotional handicap) and recorded into the master file. Each interview was transcribed in order to conduct qualitative content analysis. Transcription included a verbatim record of what was said during the interview, organized by the speaker.

To facilitate transcription, coding, and analysis of the data, this project used NVivo software, which is designed to help organize and facilitate qualitative research. Transcripts were uploaded to NVivo software as sources and each one was coded individually.

The interview transcripts were coded using qualitative content analysis. Qualitative content analysis has been used in other health research (Elo & Kyngas, 2007). Qualitative content analysis is a means of text analysis via information processing schemes (Bos, 1999). Coding is a process by which meaning is extracted from the text via a series of codes, which are systematically organized to extract meaning. The smallest unit is a code, which captures the essence and meaning of a verbal passage. Codes were typically succinct- a word or phrase (Saldana, 2013). Different types of coding can be utilized to further the purpose of the research study. An initial coding scheme was driven by a thorough review of the literature, in order to
ensure the study’s conceptual framework synchronizes with the analysis. This was critical, as the end goal was to answer the research questions that arose directly from the literature (Saldana, 2016). Based on a review of the literature, categories consisted of cognitive factors, bodily factors, device factors and personal factors. This study used a first cycle coding process of in-vivo coding, emotions coding, values coding, and implemented a second cycle coding process eclectic coding.

**First Cycle Coding.**

When a codable moment that succinctly defines an element of listening effort (such as an example of a cognitive, bodily, device or personal factor) was seen in the transcript, in vivo coding was used to manage the data while maintaining the participants own language (Saldana, 2016). This coding paradigm was used in order to maintain the subject’s perspective. Emotions coding was also used to label the feelings participants had (Saldana, 2016). These coding paradigms created nodes that gleaned factors, which may contribute to listening effort of participants. Using these coding paradigms also ensured a patient centered theme is generated which was not otherwise represented in the current literature. Codes generated from these two coding cycles were organized into sub-categories, categories, and then overarching themes (Graneheim & Lundman, 2003). Once themes were found, they can be used to explain social reality (Bos, 1999). In this instance, themes related to the greater literature to explain how listening effort influences the listening experience of the individual.

**Second Cycle Coding.**

An important aspect of qualitative data analysis is its inductive nature. Because qualitative work is best done in a manner of continuous data collection and data analysis, periodic re-analysis was be done. These re-analyses occurred after every five interviews. Initial
re-analyses involved re-reading sources from bottom to top, to ensure that each transcript was read thoroughly. After this re-reading, questions from the interview were selected, and answers were read across each source. During these readings, re-analysis occurred on three fronts- in order to check the strength and boundaries of themes found, to look for overarching patterns that emerge across interviews, and to examine disconfirming themes.

**Plausibility and Believability**

While validity and reliability are often used as hallmarks of rigor and relevance, when conducting interpretive research, the researcher’s aim is to triangulate the findings. Triangulation is the process of verifying a claim by demonstrating that multiple sources argue the same claim (Creswell, 2013; Maxwell, 2013). There are four categories of triangulation that are frequently used to establish credibility in qualitative research. These include triangulation of data sources, among different evaluators, of perspectives to the same data set, and of methods. (Patton, 1987) Three methods of establishing credibility that have been used in audiologic qualitative research will be employed in this study.

**Triangulation.**

First, triangulation occurred between two reviewers, one of whom is the student researcher, the second the major advisor. One short passage was randomly selected for each of the 19 participants. The student researcher completed initial codes of the each paragraph, and a secondary reviewer also coded the paragraphs independently. The kappa coefficient was obtained using NVivo software. This is one method to obtain credibility that has been utilized in audiologic qualitative research (Hallberg & Carlson, 1991).
Member checking.

Secondly, after preliminary data analysis, a subset of participants who indicated availability and interest were invited to re-read their own transcripts. Participants were asked to clarify any confusing or unintelligible portions of the interview, and comment on what they thought the most meaningful portion of the transcript was. Please see Appendix C for the follow-up worksheet. Participants were also invited to a meeting presenting the main findings of the analysis. Participants who attended the meeting were invited to debrief and discussed afterwards. Please see Appendix C for the list of questions asked during the debriefing session. Participants were asked to confirm or reiterate ideas found in data analysis during the meeting. Finally, the primary researcher reviewed video recordings of the meeting, paying careful attention to verbal and non-verbal expressions of agreement and support or disagreement and opposition. The use of member checking was another method utilized to build credibility, and it has a tradition of use in audiologic qualitative work (Scarinci, Worrall & Hickson, 2008).

Memoing.

The final method to establish credibility included the documentation of field notes on nuances and impressions from the interviews directly after the interviews. This journaling was utilized to help support the interpretation of the interview meanings. This process can also address and document the interviewer’s subjectivities so that the research process can avoid including as much unconscious subjectivity as possible. This process has also been used to reach credibility in audiologic research (Lockey, Jennings & Shaw, 2010).
Subjectivity.

In qualitative, interpretive work, subjectivity can be a major concern. Subjectivity is the perspective of the researcher. As the influences of a researcher can distort the findings voices, it is important for the researcher to examine their own subjectivity (Peshkin, 1988). Peshkin argues that subjectivity cannot ever be eliminated entirely, but a careful, thoughtful analysis of personal influences allows for subjectivity to become a careful part of the research process, rather than a unchecked assumption allowed to run rampant (1988). The subjectivity of this researcher was examined through the regular use of memoing and meetings with the research team to assess methodological issues such as the level of objectivity. The subjectivity of this researcher is presented for readers of this dissertation in Appendix D. In this appendix, readers may be able to understand, or at the very least, appreciate the influences that this researcher has and how they were managed so as not to draw inappropriate conclusions.

Results of Triangulation Procedures.

Between researchers.

Triangulation between researchers yielded an almost perfect kappa coefficient ($\kappa = .94$) according to conservative estimates. According to Landis and Koch (1977), kappa statistics of .81 to 1 are considered to be almost perfect. Fleiss (1981) considers any kappa statistic above .75 to have an excellent strength of agreement.

Between participants.

Out of 19 participants, 18 reported interest in participating in the member checking portion of the procedure. Nine participants replied they could attend the member checking event. All nine were sent transcripts and response sheets. Six response sheets were returned, a response rate of 66%. 
Responses included four corrections of typographic errors. For instance, “writing instructor” was written as riding instructor (P007), “deaf look” was written as death look (P007), the word “not” was omitted (P006), and the national education for assistance dog services was referred to by its acronym “NEADS”, and written incorrectly as NEEDS (P006). One participant clarified a portion of the interview that was unclear and coded as inaudible. She wrote “At the beginning, there a [sic] sentence with some inaudible parts ‘I hear almost everything depending on who’s talking [inaudible] voices are usually the best, [inaudible] voices are iffy.’ That should be male and female respectively” (P009).

Another participant chose not to clarify or change the transcript, but commented that “I felt satisfied that the transcript captured the essence of my challenges, reflections and listening effort processes based on the questions you asked. I do think there is more to factor, but it would take more time and depth which would be beyond the scope of your research at this time” (P016).

Analysis of discussion after the lecture on preliminary results findings demonstrates that participants agreed with findings and pushed for the dissemination of this research. While participants were quick to accept the results found in the study, they challenged current practices surrounding listening effort: “I think this is excellent, it really… hit all the good spots. But my thought was, okay, what’s next? How is this going to impact us, and audiologists and other people?” (P002).

Memos.

19 participant memos were written which summarized moments that needed to be captured and analyzed. Six procedural memos were also kept, which discussed issues relating to collecting data. For instance, after the interview had been completed, one participant brought up
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a relevant topic again, and an attempt to restart the recording was made, but the original was accidentally played back instead of recording a new session. A note was documented to ensure this process would not be repeated and new data would not be lost again.

An example of a participant memo discussed burgeoning themes and questions that arose from the interview process. An example of a memo was the following note “Subject mentioned “passing”. I nodded along with her as she said the bit about passing, didn’t realize until afterward that I didn’t probe this further” (Investigator procedural memo) Documenting this occasion provided insight into the investigator subjectivity and prevented it from happening again in a second interview.

Other topics discussed in procedural memos were particular interview techniques that went well, or needed to be improved. The researcher noted a predisposition to give verbal encouragers such as “mhmm”, “uh-huh”, “right” and “awesome”. Besides being tedious to transcribe, these had a tendency to interrupt the flow of the story participants told, and documenting this improved later interviews.
Results

Demographic data

Individuals were recruited through a variety of sources. Refer to Table 1 for specific recruitment locations. The majority of participants were recruited through various chapters of the Hearing Loss Association of America, though some were recruited by word of mouth through other participants in the study.

There were a number of responses to the call to participate. Several respondents responded via email or phone call. Of those respondents, three did not qualify for the study because they did not match inclusion criteria. Another ten either could not be scheduled or did not respond to calls or emails attempting to schedule an interview.

Nineteen adults who utilized hearing aids participated in this study, with a sample mean age of 56.4 years (standard deviation: 16.2 years and range: 19 to 82 years). The age breakdown in this study is consistent with the population of individuals with hearing loss in the United States (Abrams & Kihn, 2015). The sample was made up of 15 females (79 percent) and four males (21 percent).

Audiometric Information

The average hearing loss, expressed as the pure tone average of .5 kHz, 1 kHz., and 2 kHz., for the right ear was 53.2 dB for the right ear and 52.2 dB for the left ear. Figure 8 displays a graph of average audiometric results. However, it is important to note that audiometric data varied widely, due to maximum variation sampling. As such, sub-categorization is necessary to illustrate the data set. Figure 9 shows a breakdown of hearing loss types.
<table>
<thead>
<tr>
<th>Recruitment Location</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>HLAA Hear Here Hartford chapter</td>
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</tr>
<tr>
<td>HLAA Eastern Connecticut (ECC) chapter</td>
<td>7</td>
</tr>
<tr>
<td>HLAA Boston chapter</td>
<td>4</td>
</tr>
<tr>
<td>HLAA Southern Connecticut chapter</td>
<td>1</td>
</tr>
<tr>
<td>Word of mouth</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 1: Recruitment locations of participants in this study.
Figure 8: Average audiometric data of participants.
Figure 9: Configuration of hearing losses for participants.
Data obtained from interview demonstrated 10 hearing losses present at birth or diagnosed in childhood (birth-17 years), four hearing losses diagnosed in early adulthood (diagnosed during 18-64 years), and five late onset adult hearing losses (diagnosed at 65+ years).

**Self-reported hearing disability**

Subjects were asked to classify their self-perceived hearing disability using the following criteria: none, mild, moderate, severe, and profound. Results are shown in Figure 10. These self-chosen descriptions matched the respective degrees of hearing loss, with individuals with some normal hearing sloping to mild or moderate degrees of hearing loss choosing “mild” or “moderate”, and individuals with more significant degrees of hearing loss choosing “severe” or “profound”, as appropriate. The only individual that did not correspond with this pattern was a subject who had a mild steeply sloping to profound hearing loss after 2000 Hz (P010). This individual currently wore hearing aids but had been evaluated and was a qualified candidate for a hybrid cochlear implant. This individual reported significant difficulty hearing and an extreme amount of listening effort, thus, chose to classify herself as having a profound hearing disability. Also of note, is the fact that none of the subjects reported having no hearing disability.

**Occupational status**

Table 2 shows the number of participants who were employed, students, retired, or unemployed. This data enlightens later conclusions regarding listening situations participants faced.
Figure 10: Self-reported hearing disability of participants.
Living arrangements

Table 3 demonstrates the living arrangement of participants, with the majority of participants lived with other individuals—either family members or roommates. The remaining participants lived alone. This data illuminates later conclusions about listening situations participants experienced.

Highest education level

See Table 4 for educational levels of participants. It is evident that this sample was a very highly educated group of individuals. Those with doctoral degrees held them in chemical engineering, biochemistry, education, and social psychology. Some participants held masters degrees, but a subset of these participants either had completed further training beyond a masters level, or were doctoral candidates, but did not complete a dissertation. Other participants had completed bachelors and associates degrees. The remaining participants had some level of post-secondary schooling, and some of these participants were currently enrolled in academic programs.

Satisfaction with Hearing Aid(s)

Subjects were asked to rate their satisfaction with the hearing aids they were currently wearing from the following categories: very dissatisfied, dissatisfied, neutral, satisfied, very satisfied. Responses are shown in Table 5. Most participants were satisfied or very satisfied with the device. Two were neutral. Of note, the subject who was dissatisfied with her hearing aids was a retired professional musician (P017), and commented that her inability to hear music with the hearing aids led to the selection she chose. The subjects that were neutral were an individual who was a candidate for a hybrid
<table>
<thead>
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<th>Number of participants</th>
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<td>Live alone</td>
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</tr>
<tr>
<td>Live with others</td>
<td>17</td>
</tr>
</tbody>
</table>

Table 3: Living arrangement of participants.
### Educational Status

<table>
<thead>
<tr>
<th>Educational Status</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doctoral degree</td>
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<td>Advanced masters degree</td>
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<td>Masters degree</td>
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<td>Bachelors degree</td>
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</tr>
<tr>
<td>Associate degree</td>
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</tr>
<tr>
<td>Some post secondary education</td>
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</table>

Table 4: Level of education for participants.
<table>
<thead>
<tr>
<th>Satisfaction level</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Satisfied</td>
<td>6</td>
</tr>
<tr>
<td>Satisfied</td>
<td>10</td>
</tr>
<tr>
<td>Neutral</td>
<td>2</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>1</td>
</tr>
<tr>
<td>Very dissatisfied</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 5: Participants ratings of satisfaction with hearing aid(s).
cochlear implant (P010), but still currently wore hearing aids, and an individual who had an asymmetrical hearing loss (P019).

**Hearing Handicap**

Participants completed the hearing handicap inventory. Scores were reported based on subscales—social and emotional. Please see Figure 11 for scores on this inventory. Comparing across the two subscales, all but two participants scored within one categorical marker of the other scale. One participant reported a mild social handicap and a significant emotional handicap, and the other reported no social handicap and a moderate emotional handicap. The latter, was a retired professional musician who lamented the loss of music due to her hearing loss (P017). Through the interview, it became clear she was saddened by the loss of enjoying music and the ability to play as a member of a quartet. “I can’t enjoy my music anymore and that’s... the saddest thing”. This may have impacted her emotional subscale score due to questions like, “does your hearing loss cause you to be irritable”, “does any problem or difficulty upset you at all”, “do you feel that any difficulty with your hearing limits or hampers your personal or social life” and “does a hearing problem cause you to feel depressed”, and “does a hearing problem cause you to feel left out when you are with a group of friends” (Ventry & Weinstein, 1982).
Figure 11: Participant results on the Hearing Handicap Inventory.
Qualitative findings

A total of 9,077 codes were generated from the 19 interview transcripts. A text frequency search revealed the word count of popular words, ten of which are as follows: hearing (2030), (related words included hearing aids (450) and hearing loss (541)); think (890); talk (598); work (558); listen (555); wellness (510); time (455); effort (455); feel (373); want (370). For individual participants, the highest amount of codes was 834 (P013) and the lowest amount of codes was 252 (P011). These individual codes aggregated into 452 subcategories and 88 categories. Subsequently, these categories then amassed into 5 themes that encompassed underlying commonalities in these interviews. Figure 12 shows the five themes that adults with hearing aids reported as part of the listening effort experience.

The various themes that were found are generally presented in order from most to least popular codes. Throughout this document, tables demonstrating these themes and categories that fall under the theme are presented, with information pertaining to the number of sources and codes for each category. The number of sources refers to the number of participants who reported the category at least once in the interview. The number of codes is the total number a category or subcategory is referenced across all participants in the study.
Figure 12: 5 themes that emerged as a result of qualitative analysis of participant interviews.
Thematic information.

Signals & Environments.

General characteristics of signals that cause listening effort.

As a theme, signals & environments did not constitute the highest number of codes, however the issues of the audibility and the intelligibility of the signals are pervasive throughout the other themes, and as such, this theme must be addressed first. This is the only case that is presented out of order of frequency of codes. Please see Table 6 for a detailed list of categories & subcategories in this theme. For participants in this study, signals important to communication are not audible and/or intelligible, due to hearing loss. Lack of audibility causes increased effort because they “hear one word in seven.” (P007) Intelligibility is also affected. “The hearing loss affects intelligibility, because “they’re talking to you, and you hear them talking to you, but you really can’t make out the sense of what they’re saying, because [of] the high frequency loss.” (P011) These missed portions of the spoken utterance lead to greater consequences such as missing the first bit of sentences because attention is not on the signal or missing the whole plot of the conversation. From observing the number of participants who mentioned audibility and intelligibility in the interview, it is clear that the hearing loss affects the audibility and intelligibility of sounds.

There are a number of auditory signals that have been reported to cause increased listening effort by the participants in this study, these are listed below. One such signal is the characteristics of a speaker. Speakers with accents, soft voices, and fast speaking rates require more effort to be understood. Furthermore, more effort is needed to understand
A QUALITATIVE EXAMINATION OF THE LISTENING EFFORT EXPERIENCE OF ADULTS WITH HEARING LOSS

<table>
<thead>
<tr>
<th>Category</th>
<th>Sources</th>
<th>Codes</th>
<th>Code Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General signals:</strong> Audibility</td>
<td>19</td>
<td>107</td>
<td>“it take[s] extra effort to hear what is being said, because the hearing loss [makes it] quieter… different parts of the speech are… missing and there’s different pitches that I’m not gonna hear” (P009)</td>
</tr>
<tr>
<td><strong>General signals:</strong> Intelligibility</td>
<td>4</td>
<td>7</td>
<td>“There’s a lack of discrimination of the sounds.” (P014)</td>
</tr>
<tr>
<td><strong>Specific Signals:</strong> Bad signals (Difficult speaker characteristics &amp; sound quality)</td>
<td>18</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td><strong>Specific Signals:</strong> Good signals (Easy speaker characteristics)</td>
<td>3</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Categories and subcategories contributing to the theme of signals
speakers with indistinct speaking styles, whether it is due to articulation issues, stroke, or progressive voice disorders. “I've had a hard time understanding some of my students. Not my students I have right now but other students have significant speech impediments.” (P012) The high-pitched voices of children are also very difficult to hear. Speakers who are discussing private or sensitive topics often use hushed whispers, which are difficult to hear and cause increased listening effort. Finally, context of the spoken utterance matters to the effort of the patient. Some participants report that they can make educated guesses about misheard words in the sentence when there is context. “Well, when you lose a word… you can sometimes guess what it was from the context.” (P010) Increased effort is needed to understand the sentence when there is little context: “whereas with unfamiliar topics it’s harder for me to pick up on [they] just said [I]… think I have a tougher time.” (P012).

A specific signal that requires increases in effort in order to process is the telephone. A phone is challenging due to a reduced frequency ranges, potential for distortion in the sound quality, and lack of visual cues. Speaker phone settings sometimes degrade the signal further, and was noted as being especially effortful. Conference calls with multiple speakers are more challenging to follow. Many participants also reported difficulty listening to sound systems that amplify a speakers voice for the entire room, such as audio systems or intercom systems, as distortions can also make understanding more effortful. For instance, one participant described attending a conference,

I went to the people running the audio and it was very poorly done. They had one chintzy little speaker and they said well if you sit kind of farther back, because typically I sit in the front so I can read their mouths…if I can hear it and see the mouth it’s much better. So when I sit farther back where they said, I could hear a little better. Apparently the sound from that speaker was directed to that spot and I could hear a little better, but it still wasn’t enough and I was too far away. (P010)
From this quote, it is apparent that the distance and poor sound quality contributed to the listening effort experience of this subject.

Finally, there are specific signals that are difficult to hear and increase listening effort. These include proper nouns, letters, and numbers, or the combination thereof, as in license plates and client codes for a company.

*General characteristics of environments that increased listening effort.*

Questions in this interview probed participants about listening situations, which were effortful, and as such, environmental characteristics that moderate effort emerged as the most common theme. Subjects identified features of difficult environments that caused increased effort, but also highlighted environments that alleviated some of the effort experience. These specific themes are shown in Table 7. Participants reported environments with background noise of any sort require increased exertion to hear in, regardless if the noise source was conversational speech in the environment, music, television, heating and cooling systems, in transportation systems or workplace noise.

Conversational background noise is problematic, because “everybody’s talking, so it’s noisy” (P007). The noise is everywhere, “it was this group talking over here, this group talking over here, this group talking over here, this group talking over here” (P019). There are other contributors to background noise. Music occurs in locations such as bars and restaurants that “have music blasting, which I can’t hear, but it’s adding to the overall sound” (P010). Parties and gatherings may also have music. “Everybody wants background music, which really throws off the easiness of hearing” (P006). Furthermore, the “t.v. playing… adds to the background noise” (P006). Transportation can also be noisy. Cars have road noise, “there’s all this noise from the vehicle traveling” (P006).
Planes are also loud “to this day, I still can’t hear on a plane” (P002). These additions to
background noise are quite common, as “everyone wants something going on in the background” (P006).

Finally, workplace noise obviously varied with the job setting of the subject, but there were several reports specific to occupational noise. One subject volunteers at a homeless shelter as a line cook during breakfast and reported “any kitchen background is wicked noisy…the tin pans banging” are problematic (P018). Another subject is a biochemist, and has worked in laboratories conducting experiments at the bench. She reported that technical machinery such as centrifuges can often be very loud, as seen in this excerpt “lab, where there may be instruments. Any background noise for me is a killer” (P013). Generally speaking, noise of any type is a nuisance because “it always seems to come at a critical word and it obliterates the word”, which alludes to the audibility and intelligibility discussed earlier (P011).

Groups were also reported to be effortful. Groups ranged in size from “four or five” (P005) to “eight guys” (P004) to “about 150 people who are talkative and noisy” (P015). It seems that group size is related to the level of background noise, as “the bigger the room is, the more people… and the louder everyone gets” (P009). Furthermore, in groups, multiple conversations are often occurring. It is not just “one conversation, because there’s usually two or three going on at one time, which can be really difficult” (P001).

The acoustics of a room were also noted to increase effort for this sample of individuals wearing hearing aids. Participants used words like “reverberation” or “echo” to used to describe challenging listening situations. Furthermore, in illustrating difficult listening situations, participants described large, open spaces with hard surfaces & floors, few absorbent materials, and high ceilings.
Relating to acoustics, the location of the signal in the environment can contribute to increased listening effort. Participants reported that listening to sound spread over a distance is effortful “I'm up in my room and they're talking to me from the kitchen downstairs and yelling up at me and even if it's something like ‘dinner's ready’, I’ll often have a tough time with that” (P012). Participants also reported that hearing people from behind is also effortful. Seating arrangements can contribute to increased listening effort, as the sound source is not always in an ideal situation. Participants commented that seating arrangements in a row, such as a across a long conference table or a bar can be challenging for a number of reasons. This spatial set up can be challenging because the sound source can be at a distance and visual cues are limited. Furthermore, seating arrangements in the middle of the room can also be challenging, because information can arrive from any direction, and also, background noise is present on all sides. Subjects also reported difficulty listening when the sound source was moving. Especially difficult was listening to people who are “walking [and] they’re talking… I might get the middle part of the conversation” (P016).

Specific effortful listening environments.

There are a number of specific environments that were reported to cause increases in listening effort. Restaurants, coffee shops, bars and cafeterias are effortful due to the high levels of background noise and reverberation. Flying in planes, driving in cars, riding a subway or bus, are also difficult due to background noise, the lack of visuals cues from pilots, drivers, or passengers in the vehicle, and the state of vigilance the person with hearing loss must remain in. Participants stated that in the past, they had missed stops or flights because they didn’t hear announcements. “For the duration of the ride, be it long or short, I must remain on high alert because otherwise I might miss my stop” (P006). Additionally, parties, celebrations and get-
togethers can be effortful. Holidays, cocktail parties, and weddings are usually associated with large gatherings, which have multiple speakers contributing to the background noise, and are sometimes held in acoustically challenging spaces with background music. Work was a specific environment that was frequently listed as challenging, however situations varied widely depending on the participant and the work setting. Trade shows, conferences and conventions where the job requires conversation with unfamiliar prospects in a large convention hall setting with high ceilings, poor acoustics and background noise can be effortful. Other participants in office environments commented on open office floor plans or office masking noises increasing listening effort. Job duties that can cause increased listening effort such as talking on the phone and group meetings are discussed elsewhere in this dissertation, however, poor work environments can exacerbate these situations. Theaters are challenging environments due to the lack of visual cues and audience conversations distracting the listener. Other specific environments that were reportedly challenging were waiting at the bank, the DMV, or doctor’s offices. Participants reported increased levels of vigilance during these situations.

“I cannot relax for fear of not hearing when they call for me. It is another situation where I must remain at high alert. It is not always possible to sit strategically because the best hearing seats are often taken. Almost all places have a t.v. playing which adds to the background noise and my internal stress. If the wait is a long one [in doctors offices] I often worry that my name was called and I missed it. I usually bring a book but can never relax enough to read it.” (P006).

Furthermore, classes and meetings with lecture environments are also challenging because rooms tend to be large, open spaces. The material that is to be heard can impact grades or job performance, which increases the level of motivation, but also stress. There are typically distracting noises, such as coughing, shuffling papers, dropping books or squeaking chairs. Also, questions from the audience are often unamplified and at a distance. Another environment in which increased listening effort is the yoga studio. Although it seems antithetical, yoga studios
can be significant sources of stress for participants in this study, due to a lack of visual cues and the use of music contributing to background noise. Furthermore, yoga studios tend to be large, open spaces with hard surfaces, and high ceilings. Yoga instructors often speak with soft, calming voices, which require effort to hear.

In contrast, there are a number of environments that are preferred by subjects in the study due to the ease of listening. Favorable environments are acoustically sound with appropriate amplification, carpeting, curtains, sound paneling, and structures to reduce reverberation and funnel the signal of interest toward the listener. Participants reported preferring quiet venues with silence or little background noise. Certain areas of restaurants are more favorable than others, with subjects reporting they prefer to sit in a quiet corner, away from the bar and the kitchen. Subjects also prefer sitting in circles around one small table, in order to maintain visual contact with the other members of the conversation. Some participants prefer to relocate to quieter environments, such as libraries or a private home, where the environment can be carefully controlled.

Mediating factors that impact listening effort.

While there a number of effortful listening situations have been reported, participants readily adapt and implement strategies to improve communication and alleviate listening effort. The motivation levels of an individual can also impact the listening effort experienced.

Anticipatory strategies.

Table 8 lists the anticipatory strategies used by participants in this study. Anticipatory strategies are approaches used to prepare for the communication interaction (Tye-Murray, 1998). Anticipatory strategies included wearing amplification and using assistive listening devices. Participants reported that hearing aids help considerably in reducing listening effort, in that they
increase audibility of the signal. Subjects also reported wearing hearing aids had emotional and physical impacts on their lives. Hearing aids help to reduce physical manifestations of the hearing loss. “But after I got my hearing aids, I ended up realizing how tense my body is when I’m not wearing them. That clicked, that was an ah-ha when I got the hearing aid, to realize how much physical effort is put into hearing.” (P016) Other participants reported similar feelings without hearing aids, “in my shoulders, feeling a little bit cold, a little drawn in” (P013).

Emotional processes relating to listening effort are also moderated by hearing aids.

“The big change for me was the doubt… I realized how much energy I was using trying to focus on what people were saying. Because in my mind, I was listening to what they were saying, but I was also repeating in my mind what they were saying to make sure I heard it correctly. And then I would reiterate the topic to make sure what they said was correct. So sometimes I was saying it two or three times, whether it’s one time to myself and then one time to them, or repeating it a few times to myself, and then actually clarifying with them” (P008).

Though the hearing aid helps to reduce listening effort caused by hearing loss, subjects also reported that they modify the hearing aid in order to optimize hearing during difficult listening situations and to further reduce listening effort. Of these modifications, subjects mentioned changing programs most frequently. Some participants mentioned changing hearing aid settings when in specific noisy situations such as restaurants. Other participants changed programs in response to increased listening effort, “I was almost lurching across the table trying to hear and then I’ll start fiddling around with the programs on the hearing aid and I don’t have too many programs… so I kept putting it between comfort and master and trying to figure out which would be the better” (P003). Some participants referred to a specific hearing aid technology, such as directional microphone, noise reduction, or frequency compression when discussing amplification changes. “[I would use] the directional mic… if I was in a restaurant” (P002). “Not
### Anticipatory Strategies

(Amplification, Assistive listening devices, DIY, strategic seating, familiarity, phone, TV, captioning, streaming devices)

<table>
<thead>
<tr>
<th>Category</th>
<th>Sources</th>
<th>Codes</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticipatory Strategies</td>
<td>19</td>
<td>334</td>
<td>“I was almost lurching across the table trying to hear and then I’ll start fiddling around with the programs on the hearing aid and I don’t have too many programs… so I kept putting it between comfort and master and trying to figure out which would be the better” (P003).</td>
</tr>
</tbody>
</table>

Table 8: Categories and subcategories contributing to the theme of anticipatory strategies
only did they amplify sound, but this particular hearing aid, if I understand correctly, shifts the dynamic range from where I have no hearing and shifts it somehow into the hearing range” (P016). This level of specification was not present in each interview, as most subjects vaguely reported they changed a setting in their hearing aids. “There’s a setting… it’s supposed to bring the sound in, so I’m not getting so much background noise. I’ll turn that on in restaurants” (P009). Participants also report changing volume in order to improve listening in effortful situations. “AM: So what will make you switch the volume? What’s the trigger? P013: The ability to understand speech. AM: So if your speech understanding goes down… P013: I turn it up.” Subjects also reported plugging vents in earmolds, and using smartphone apps connected to hearing aids in order to make adjustments. It is clear that hearing aids assist in reducing listening effort in a variety of ways. However, hearing aids do not reduce effort completely, as listening effort persists even when wearing amplification.

To combat this problem, subjects reported utilizing other technology to assist in improving hearing and reducing listening effort. Many subjects used an FM system or other wireless devices such as a Roger Pen for additional benefit in effortful listening situations. “The FM is, it goes from like a 2 to a 10. I mean it’s like, the hearing aids help, but my life doesn’t change at all... if I have my hearing aids or I don’t have my hearing aids, it’s pretty much, I’m struggling. The FM is like bang! I mean, I can’t get over what I can hear.” (P014) Other devices that were used were streamers and loop technologies for the television and the phone.

There are a number of other strategies that are also used to combat listening effort. Visual cues are one factor that can be employed to reduce listening effort. Subjects report using speech reading as a supplement to the auditory signal. “As long as I can hear the sound and see your lips, I have much better word understanding” (P010). Subjects also reported selecting specific
seats in order to reduce listening effort, and oftentimes seats are chosen based on where visual
cues can be obtained. Moreover, in lectures, meetings, or classes, subjects reported choosing
seats nearest to the speaker, or near an amplification system. In party situations, subjects will
often position themselves near a familiar speaker. Participants with asymmetrical hearing losses
also discussed angling their better ear towards the sound source.

Captioning is used to convert auditory signals into visual ones, such as subtitles for a
movie. Caption call phones were often mentioned as a method to alleviate difficult listening
conditions on the phone. “I was exclusively using captions [on the phone]” (P015). Likewise,
closed captioning ameliorates difficulties when watching television. Communication Access
Realtime Translation (CART) technology was also used by participants in large meetings.

Another strategy to reduce listening effort is to seek out a familiar speaker, as participants
mentioned they experienced less effort with family and voices they knew well. “I lock onto [my
wife’s] voice... her voice is so familiar to me that I have no difficulty in locating which one it is”
(P001). Participants also mentioned less effort with topics and vocabulary they were familiar
with, as opposed to unfamiliar topics.

Subjects reported using a variety of pre-emptive strategies when on the phone, such as
employing captioning technology, or binaural phone programs in order to improve
communication and reduce effort. “The phone can be challenging. I always coach people, you
have to speak really slowly, thank you for being so helpful to me... it’s the same script...” (P015).
Subjects also report relegating as much communication as possible to non-auditory forms, such
as email or text messaging.

An additional strategy that is employed in preparation for conversation is controlling the
environment. Participants report choosing job opportunities and professions in which they felt
that they would be able to better communicate in order to reduce listening effort. Participants also report once the environment cannot be controlled, emotional reactions occur. These reactions will be discussed in a later section.

In addition to controlling the environment, participants also mentioned offsetting listening effort at school and in their everyday lives through extra preparation. Participants with hearing loss in childhood recalled taking schoolwork home to complete with less noise in the environment, and often completed more than was assigned to ensure understanding. “I would take my… work home and do it at home, because it was a quieter environment and I could focus on what I needed to do instead of getting distracted by the kids goofing off and playing around in the classroom.” (P008) Participants diagnosed with hearing loss later in life also discussed reading extensively in order to gain contextual knowledge needed to compensate for lapses in auditory messages. While not directly related to extra energy expenditures in order to hear an auditory message, these are aspects of the hearing loss experience that require extra effort on behalf of the individual.

Participants also understood that in communication interactions, they would need to employ all of their resources on understanding the auditory message. Participants reported the inability to multitask, as energy must be directed on the listening and understanding process. “If I’m listening that’s what I have to do- is listen.” (P008) Another participant reported “my listening is reading lips and facial cues, and everything else. It removes my ability to multitask.” (P014) These comments suggest the extra allocation of cognitive energy in order to understand the auditory message. Cognitive strategies and cognitive components of listening effort are discussed elsewhere in this paper, however, participants understood the need to expend extra effort and the fact that they cannot multitask even before the interaction occurred.
Participants also often prepare for communication by prefacing the interaction with an explanation of their impairment. “I start with I’m hearing impaired, you need to go slowly” (P014). Another participant has a script she routinely uses: “I have a severe hearing loss so if you can speak little bit slowly, and with volume, that would be a huge help to me” (P015).

Still, there are other strategies that are employed previous to potentially effortful situations. Many participants have utilized federal rehabilitation services in their quest to improve listening and listening effort. Others use service dogs to raise awareness about their hearing status and to reduce the state of hyper-vigilance that results from constantly scanning the environment for sounds. Yet, other participants receive aural rehabilitation services in the form of auditory training in order to practice in difficult listening environments in order to better compensate for challenges caused by listening effort. Types of training utilized by this sample includes KTH speech tracking training with a teacher of the deaf (Gnosspeilis & Spens, 1992) and computerized LACE training (Sweetow & Henderson-Sabes, 2004).

Repair strategies.

Repair strategies are used to better understand the auditory message and reduce listening effort after a communication breakdown. A number of repair strategies were employed by participants in this study, as seen in table 9. Listeners with hearing loss will often request the communication partner to assist in understanding a missed portion of the message. These requests include asking the partner to repeat or rephrase the missed portion of the message, to speak with more volume, to slow the rate of speech down, to speak with more articulation, and to spell the missed word. Debriefings, fact-checks, and summaries were also common in order to confirm information “I reiterate the topic to make sure [my perception of] what they said was correct” (P008).
<table>
<thead>
<tr>
<th>Category</th>
<th>Number of sources in category</th>
<th>Number of codes</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repair Strategies: (Requests, fact-check, fake, adlib, “bullshit”, change environment, hearing buddy)</td>
<td>18</td>
<td>63</td>
<td>“…as the conversation ended, I asked my business partner, well, what did you basically say? I needed a summary, I needed a debrief…” (P004)</td>
</tr>
</tbody>
</table>

Table 9: Categories and subcategories that contribute to themes of repair strategies
Participants also mentioned trying to manipulate their physical environment in difficult listening situations. When faced with increased listening effort, listeners will request to move the conversation into a better listening environment. “Can we step out into the hall?” (P013)

Participants may also request to “go somewhere else a little bit quieter” (P003) or “if they have me on speaker phone, will you take me off speaker phone? I’ve actually asked that.” (P004).

Also, as stated before, participants will often seek locations that provide access to visual cues in order to reduce the amount of listening effort. Another strategy that is sometimes used during particularly difficult listening situations is the recruitment of a hearing person to assist during periods of extreme listening effort. Friends, family, and professional colleagues can often field phone calls, or repeat and rephrase misheard data. Finally, participants acknowledged when difficult listening situations occur, and the effort experience is too demanding, they may fake, adlib, or bullshit the conversation. Some participants commented on passing as a hearing person, which meant that they were faking their role in the communication interaction, but very little was actually audible and understood by the person with the hearing loss.

**Cognitive strategies.**

There are a variety of strategies used by participants in this study, which employ greater cognitive resources to understand the signal of interest. These are shown in Table 10. For instance, one member reported that she used extra energy when following a conversation because she “... was listening to what they were saying, but I was also repeating in my mind to make sure I heard it correctly” (P008). This mental repetition was used to ensure that what was heard was logical, while simultaneously participating in
<table>
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<tr>
<th>Category</th>
<th>Sources</th>
<th>Codes</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Strategies</td>
<td>14</td>
<td>62</td>
<td>“... I was listening to what they were saying, but I was also repeating in my mind to make sure I heard it correctly” (P008)</td>
</tr>
</tbody>
</table>

Table 10: Subcategories that contribute to the category of cognitive strategies
the conversation. Other participants mobilize extra effort to understand, fill in gaps, and pay extra attention.

**Lifestyle strategies.**

Through this qualitative study, it became clear that as a result of the exertion, participants with hearing loss need to make lifestyle changes to reduce the amount of listening effort. As such, there is a class of strategies that are used specifically to alleviate the effects of listening effort shown in Table 11. These include leading a healthy lifestyle by allowing for adequate rest and recovery periods during the day, relaxing and reducing stress, exercising, sleeping enough at night, and eating a healthy diet. Participants also reported the need to take amplification out for periods of non-active listening stating the need to “take out the hearing aids… to unwind and… have a tea and I might read [or] something that I didn’t have to listen to anything.” (P006)

**Motivation.**

An important factor that moderates the listening effort experience is how much motivation the participant is willing to put forth. One participant explained the difference between exhaustion from activities he is motivated to do- kayaking- and activities he is not motivated to do- listening in a meeting:

I’ve had a good time paddling, yes I’m tired, but well-earned tired. And hearing or lack thereof, that’s empty. God it’s like, what did I just do? I am beat. I am physically and mentally beat. Whereas paddling, I’ve probably got a rush of adrenaline and I’ll tell you forever how much of a good time I had. I might be almost falling asleep on you because I’m so tired. And the tail end of that overwhelm, I’d go to bed tired and say oh my God I’m pooped. Well you get up in the morning and you know you’ve got a continuation of the meeting that just pooped you out, you’ve got to get yourself going and get into it again. Now, you know how that would go. You get bummed out before you even start. (P018)

There were several instances where participants were willing to go to noisy, reverberant
<table>
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<tr>
<th>Category</th>
<th>Sources</th>
<th>Codes</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifestyle Strategies (Healthy lifestyle, diet, exercise, rest, breaks)</td>
<td>11</td>
<td>47</td>
<td>“It can be exhausting. I find that by working out, proper eating, proper diet, a good night’s sleep, I find that gives me energy to get through the day, having to focus and be attentive...” (P004)</td>
</tr>
</tbody>
</table>

Table 11: Categories and subcategories that contribute to the category of lifestyle strategies
conditions due to motivation - playing music in a band, going out to eat with friends are some examples.

**Personal factors of listening effort.**

Personal factors of listening effort consisted of two major subcategories, social functioning and emotional functioning. Please see Tables 12 and 13 for categories and subcategories that contribute to personal factors of listening effort. Generally, social relationships were a common theme that emerged from the data corpus. Participants referenced the support they received from family, friends, and coworkers as a positive influence on the listening effort experience. One participant shared that their daughter alleviates the effort for her, because “when somebody says something that she figures I probably didn’t hear, she’ll just tell me.” (P002) Other participants shared that their spouses do the same: “If we’re out at a party, he very often will catch at my eye, and say are you getting this, because he understands how hard I have to work to get it.” (P015). Participants also mentioned that when in difficult listening situations, their loved ones are aware of how to mediate the effort by looking for situations that are acoustically desirable. An example of this is: “my kids look at acoustics. When we go in a restaurant, they’re like the search team, they go into the restaurant, they look around, they pick the table, and they’re looking [for things like] drapes and carpets” (P015). While there were numerous examples of social support, there were also a number of examples where participants did not receive the support needed to hear and communicate. Subjects with hearing loss from very early on in childhood report instances of being bullied by other children. Even subjects with adult onset hearing loss shared instances where their peers were not supportive: “I don’t know if they’re receptive or not, I mean they might say they are, but as time goes on, it doesn’t appear that they are receptive because they’re not making an effort to talk to me face to face, they’re not
making an effort to talk to me before they speak.” (P008) Participants shared times where accommodations were requested and refused:

> We got seating arrangements, and I had told them over a year ago saying please make sure I’m up against a wall or in a corner, so that something will catch the sound, as opposed to leaving me in the center… which would be problematic… So the seating arrangements come, and I said to my boss, “Can I see where I’m sitting?” And the response was “No. No you can’t because we’re not telling anybody until we get there.” I said “Well, you know I’m not asking for like special favors or whatever, let’s make sure we’re proactive.” And the response was “Well if you don’t like your seat, the commissioner said in six months you can put in for a request to move.” And I said, “You know I’m sorry, you want me to not be able to do my job for six months.” I wrote an email… saying… you need to recognize that 1) it will put up a barrier, I won’t be able to do my job, which I’m concerned about and 2) you know it does add to my frustration and my anxiety you know the fact that I have to work this much harder to be able to do [my job]” (P014)

These instances where support is not received can be doubly effortful. The subject must fend for themselves in a less than optimal listening situation, but the lack of support can be hurtful and cause emotional reactions such as frustration and anxiety, which impede easy understanding.

Several participants reported a unique phenomenon referred to as the “deaf look” or the “deaf stare”. One participant had a member of Deaf culture explain “you’re focused on my face, you were reading my lips, she said I knew right away. She said and I realized you didn’t have hearing aids and I wondered if you knew how intense you were” (P007). Other participants stated that they’ve been told they stare, while other participants described how they may look intense: “When I was in the counseling program we’re constantly critiqued and evaluated. And one of the ones that kept coming back to me was “She’s so intense.” And I kept thinking to myself, well I’ve been through a lot, I’m
### Table 12: Categories and subcategories that contribute to the category of social components of the personal theme listening effort

<table>
<thead>
<tr>
<th>Category</th>
<th>Sources</th>
<th>Codes</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Support (Hearing buddy)</td>
<td>15</td>
<td>99</td>
<td>“It wasn’t until I got into college... I met a guy who had two hearing aids and it was the first person I had to talk to about hearing loss” (P002)</td>
</tr>
<tr>
<td>Lack of social support (Isolation, being marginalized, bullying, judgment)</td>
<td>14</td>
<td>67</td>
<td>“I tried to train them to give me what I needed... [there was] a realization that I was no longer fully there” (P015)</td>
</tr>
<tr>
<td>“Deaf Stare” or “Deaf Look”</td>
<td>4</td>
<td>12</td>
<td>“I’m aware my body language or facial expressions might give away that I’m trying to follow, and I worry that maybe someone will think that I’m annoyed at them, which obviously I’m not” (P001)</td>
</tr>
</tbody>
</table>
serious- I never associated it with my hearing.” (P016) Due to the intensity of the focus in order to communicate, participants can experience some social misunderstandings: “I’m not saying anything offensive, it’s just the way I come across” (P007) It is clear that hearing loss is an isolating condition not only due to the reduced audibility that can occur but also the effort put into listening can cause social awkwardness, which may further isolate subjects. This contributes to the effort experience.

**Emotional components of listening effort**

An important finding of this study was the emotional consequences of listening effort. A variety of emotions were mentioned within the context of the interview, and can be distilled into several basic emotions of fear, frustration, sadness, stress, embarrassment, doubt and anger. It should be noted that many of these emotional reactions occur simultaneously within a larger emotional process. “Listening effort… it’s layered with so many psychological and emotional things.” (P015)

Fearful reactions included participant reports of anxiety, nervousness, worry, overwhelm, panic, dread, trepidation, terrified, freaking out, and desperation. Fearful reactions commonly resulted from concerns about mishearing conversation, which can have significant consequences. Two participants reported they had missed planes and bus stops due to missing important auditory cues: “[There’s] anxiety…What did I miss? Am I going to be able to make the gate? Am I going to be able to make the next connection, or whatever it is?” (P002). This fear can lead to stress and vigilance in subsequent
<table>
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<th>Category</th>
<th>Sources</th>
<th>Codes</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fear (Anxiety, nervousness, worry, overwhelm, panic, dread, trepidation, terrified, freaking out, desperation)</td>
<td>13</td>
<td>43</td>
<td>“...I’ll say something but there’s always that fear that I didn’t hear them right...” (P006)</td>
</tr>
<tr>
<td>Frustration</td>
<td>12</td>
<td>30</td>
<td>“usually I’m fine, I’m just trying to concentrate more, but there have been times when I get really frustrated and tune out and stop talking.” (P005)</td>
</tr>
<tr>
<td>Positive Emotions of Listening Effort (Acceptance, relief, hope)</td>
<td>10</td>
<td>18</td>
<td>“I just accept the fact that I’m not going to hear everything…I just learn to try and accept it for what it is, make the best of it, try and give myself the best opportunity.” (P004)</td>
</tr>
<tr>
<td>Sadness (Depressed, miserable)</td>
<td>5</td>
<td>15</td>
<td>“Sad, angry, frustrated, left out. Unseen...” (P013)</td>
</tr>
<tr>
<td>Stress</td>
<td>5</td>
<td>12</td>
<td>“It’s totally stressful... in such a way that you avoid situations.” (P002)</td>
</tr>
<tr>
<td>Embarrassment (shame)</td>
<td>4</td>
<td>10</td>
<td>“I was very embarrassed by it, to me it seemed like a weakness.” (P014)</td>
</tr>
<tr>
<td>Anger (cranky, short)</td>
<td>4</td>
<td>8</td>
<td>“It’s the fact that I can’t do anything more about it...I’ve reached my limit and... they’re not helping me” (P010)</td>
</tr>
</tbody>
</table>

Table 13: Subcategories contributing to emotional components of listening effort.

situations. However, fearful reactions also may occur as a result of concerns over social interactions.
You feel you’re not understanding what people are telling you, you start to worry that you’re missing the plot of the conversation, and that can be quite disturbing… You worry to some extent that people will misinterpret your frustration as being testy, you’re disagreeing with them, whereas actually what you’re doing is desperately follow the conversation… I’m aware that my body language or facial expressions might give away that I’m trying to follow, and I worry maybe someone will think I’m annoyed at them which obviously I’m not. (P001)

This is echoed in a second participant’s response, which highlights an effortful listening situation, the withdrawal from the conversation, and the fear about the social repercussions of misunderstanding:

It’s easy to not pay attention because it’s so much work because a lot times there’s two conversations at once so which one do I listen to? This one here or this one here? So sometimes I’m back and forth and then I kind of get bored [and] sometimes I’ll say something but there’s always that fear that I didn’t hear them right, sometimes I might say something and that’s not what they were talking about so I feel like a fool. (P006)

There is also fear regarding the extreme fatigue and forgetfulness that results from listening effort. Several participants reported that were so tired, they thought there might be a disease process at work, because no amount of rest could help the fatigue. Another subject worried that she had dementia:

One of the things that I found very disturbing was that I would attend large business meetings. And somebody would talk to me about something that had been said in the meeting, and I wouldn’t remember it, and I would be saying to myself “Oh my god, I sat in that whole meeting and she’s telling me something I have no recollection of.” And so, I convinced I had some kind of dementing illness, I didn’t tell my husband…I said well I’d go in and talk to the doctor about this but I’m not going to do anything about it because it’s not a treatable thing, if it’s happening, I’ll go in and find out exactly what’s going on and then I’ll break it to my husband. I had no idea. And it was a horrible thing to live with. (P013)

This excerpt describes a situation where the signal was more than likely not audible, and the participant assumed that she didn’t remember it due to dementia, instead, hearing loss impeded the signal, which prevented accurate memory. Participants also feared the progression of hearing loss and following in the footsteps of their parents, who had poorly managed their hearing losses.
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“So it’s progressive and I saw that with my dad, I saw it with my grandmother… when the questionnaire asks about anxiety, I… think about what I’m going to be like when I’m very old.” (P007)

Frustration was another commonly reported emotion. Participants were acutely aware of their own limitations in understanding: “I’m missing a greater percentage, so… the confidence goes down, the frustration goes up.” (P004) Frustration can lead to withdrawal, “usually I’m fine, I’m just trying to concentrate more, but there have been times when I get really frustrated and tune out and stop talking.” (P005) Frustration can also be directed at the communication partner: “I think there’s frustration with other people when they don't want to make that effort to repeat something they've said… It’s not necessarily me upset that I have a hearing loss. It’s the frustration with the other people.” (P009)

There are some positive emotional reactions in response to listening effort. Some participants have reached a stage of acceptance and recognize listening effort as an effect of hearing loss that needs to be managed. “I just accept the fact that I’m not going to hear everything…I just learn to try and accept it for what it is, make the best of it, try and give myself the best opportunity.” (P004)

Despite some level of acceptance, facing listening effort is challenging and does cause negative emotional reactions. Sadness & depression can occur in response to missing parts of communication interactions. One participant described the emotional reactions to a situation in which she was struggling to hear & had been refused accommodations: “Sad, angry, frustrated, left out. Unseen. And then, when I gave my own talk, I was taking questions from the audience, and leading up to that, I was scared I wouldn’t hear them” (P014) From this, and similar responses, it is clear that the listening effort experienced and events in an individual’s life can cause
Another emotional reaction that was evident in the interview corpus is a consistent stress response. “My stress levels are already [high] because I know I’m going to be dealing with a situation where… I’m going to be straining to hear what’s going on.” (P007) This stress was to be linked to fatigue: “Communication is stressful, it’s tiring.” (P001).

Embarrassment was a common emotional reaction that occurs after a misunderstanding. Several instances were reported in the interview corpus. “She was like how do you spell this word and I started spelling it and she just laughed… she's just like that is not the word I said.” (P012). Another participant recalled: “[A] woman who was saying something and smiling, so I was smiling too… she was smiling when she was conveying really bad news that her mother had just died, and so those things are a little awkward.” (P013) While these seem removed from listening effort, these embarrassing interactions embarrass the subject, who may then expend more effort in another situation in order not to have a repetition of the initial embarrassing moment.

Another common emotional reaction was anger. Anger often occurred because of the situation causing listening effort. However, at times, the anger was directed at the individual with hearing loss as well as their conversation partner. “AM: Where does the anger come from? Is it about them? Is it about you? P010: It’s both. It’s the fact that I can’t do anything more about it. You know, I’ve reached my limit and the fact that they’re not helping me.” (P010)

It is evident that difficult listening situations can trigger a variety of emotional responses in this group of individuals with hearing loss. Participants reported several crisis moments where they realized that they could not cope with the listening situations and the emotional responses. Finally, it is important to note that other emotions were reported, but did not reach saturation,
which supports the idea that there are a myriad of reactions to hearing loss and to listening effort that are individually determined.

There are a number of behavioral responses to emotional reactions that were observed. Several participants mentioned instances in which emotions spilled over into tears: “I came home and I just broke down crying.” (P007) Additionally, “when my cup overflows, it overflows into tears and frustration.” (P008) Another participant commented, “my frustration level goes through the roof, and the way that I deal with it, usually, is to, I have to exit because it makes me upset. I don’t get angry, I get cry-ey [sic]. And I’m not a weepy person, but it’s something that you physically can’t fix.” (P014) There are definite cognitive costs to these emotional reactions: “if you’re being emotionally triggered, or if you’re feeling sad, if you’re feeling panicked, if you’re feeling worried, that uses up some of your cognitive resources” (P015).

**Cognitive effects of listening effort.**

There are a number of references to the cognitive aspects of listening effort shown in Table 14. Participants mentioned processing, attention, and comprehension in difficult listening situations. “I’m trying to process as much as I can, as quick as I can.” (P007) There are a number of cognitive strategies that are often used in coping with listening effort. “All the brain cells are firing.” (P016) Participants mentioned expending extra effort by “using everything you’ve got” (P015) and “listening with everything we’ve got.” (P016) Participants also reported having to marshal resources in addressing listening effort. Verbs such as try, work hard, hang in, keep up, persevere, and really listen proliferated the transcripts of adults with hearing loss. A need for mental breaks and listening breaks was common across participants. Cognitive functions were also mentioned, as subjects report the need for concentrating, focusing, analyzing, thinking,
paying attention. Guessing, filling in the blanks, and figuring out gaps are used during periods of listening effort.

**Physiological effects of listening effort.**

Table 15 illustrates a number of physical responses to situations with increased listening effort. Fatigue was the most common physical response. Participants used adjectives such as exhausted, tired, worn out, wiped out, drained and empty to describe fatigue, and also mentioned mental and physical tiredness. It appears the fatigue is resultant from the increased pressure: “stress, the most obvious symptom of it is the tiredness” (P001) Participants described the intense fatigue as unlike any they had ever felt before: “I just feel like a washcloth and you squeezed it dry. That’s how I feel.” (P009) Another participant commented:

And it’s a type of fatigue that, to me, has no type of analogy that I can give you, because it is unlike any other kind of fatigue, and the degree of a depletion that it brings with it, um, is startling. The closest I can think of is about with influenza, except the physical depletion isn’t quite there. You know, with influenza, physically your body feels very injured and recovered… I don’t have my body feeling injured and recovering, but the feeling I have is that I’m not good for anything. My brain is no good. (P013)

From these quotes, it is clear that fatigue is related to listening effort. Participants also
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Table 14: Categories and subcategories that contribute to the theme of cognitive aspects of listening effort

<table>
<thead>
<tr>
<th>Category</th>
<th>Sources</th>
<th>Codes</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing</td>
<td>14</td>
<td>66</td>
<td>“I’m not just processing their content, I’m also trying to extract comprehension” (P007)</td>
</tr>
<tr>
<td>Attention (Vigilance)</td>
<td>15</td>
<td>52</td>
<td>“…I cannot relax for fear of not hearing when they call for me…” (P006)</td>
</tr>
</tbody>
</table>

reported feelings of tension during periods of stress and frustration. Possibly related to tension, feelings of pain were also discussed in relation to listening effort. Reports of headaches and
migraines were common in response to noise. Back, neck and stomach pain are also common. These appeared to result either from increased tension or leaning forward and other postural changes while straining to hear. Finally, participants measured respiration changes and feeling cold during periods of increased stress and listening effort.

**Timecourse of listening effort**

From reported subject experiences, it is clear listening effort does not occur during a singular moment of a conversation, but rather, across the course of repeated interactions over a day, a month, a year, and a lifetime of hearing loss. Some participants experienced the effects of listening effort “everyday” (P014), “every minute of every day” (P016) The effects of listening effort appear to be cumulative. “[I was] anxious to go back to work the next day because I would go through the same thing” (P002) Listening effort also is a pervasive component of an individual’s life. It occurs “pretty much constantly (P008). Another participant commented: “you can reduce the amount of effort but I don’t think you can take it all away. It’s always there, you can’t get away from it” (P001). Furthermore, alleviating listening effort is inherently effortful in of itself. “AM: It sounds like managing your hearing loss was challenging. P019: It’s a part time job.”
Fatigue (Exhaustion, tired, sleep, worn out, empty, drained) 12 101 “I’m usually tired at the end of the day... from listening all day” (P009)

Pain 5 10 “It was noisy and on top of the noise everyone wanted to blare radios, and I would always go home with such a headache because too much noise all the time drives me crazy” (P006)

Table 15: Categories and subcategories that contribute to the theme of physical aspects of listening effort

Other facets of listening effort
At this time, one definition of listening effort describes the phenomena as encompassing the mental energy needed to attend to an auditory message (Pichora-Fuller et al., 2016). However, reports of participants in this sample of adults with hearing loss who wear hearing aids suggest there are other aspects of the hearing loss experience that are effortful. These experiences are highlighted below.

**Advocacy Effort**

Participants discussed that advocating for their hearing losses in difficult listening situations was effortful in of itself. The tedium of asking conversation partners to repeat or rephrase often grows tiresome. “It’s boring to have to say that all the time” (P013). Another participant commented: “I have to…keep saying what did you say? And that gets irritating.” (P006) Furthermore, participants are often continually asking for help, but not necessarily receiving the needed supports. “Advocacy is only good if you’ve got an environment that’s receptive to it.” (P002) One participant related the effort that comes with advocacy to the medical and social models of disability. “P009: That’s really what the social model of disability focuses on. Like, if society would want to help people with disabilities without being so stubborn against even paying attention to someone with a disability… AM: that would help the advocacy effort. P009: Right, so it becomes a question of is the person with a disability required to fix themselves so that they become normal to a degree, which is… medical, or does society need [to]?” (P009). It is clear that advocating for a hearing loss in less than supportive environments is an effortful experience.

**Anticipatory Effort**
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This sample of adults with hearing loss reported a variety of strategies that are employed before communication interactions in order to improve communication and reduce listening effort. However, there is a secondary component of listening effort that occurs in the moments after an individual with hearing loss has attempted to mediate the strategy. “I think the anticipation about whether or not it’s actually going to work, I don’t know if it’s listening effort… I guess I have to- for the purposes of your study- but it’s hard to separate out, the anticipatory stress and anxiety.” (P015)
Discussion

The purpose of this study was to systematically define and describe the listening effort experience, using interpretive methodology in order to investigate insights from those with hearing loss. Analysis from 19 transcripts of participant interviews revealed 5 themes relating to listening effort: signal and environmental factors, mediating factors, physiological effects, cognitive factors, and personal factors.

Currently, the literature on listening effort focuses on signals that contribute to listening effort, technology that ameliorates listening effort, personal characteristics that can moderate listening effort and documenting physiological reactions of the body in response to increased effort. This study adds to the literature by providing a patient perspective of the listening effort experience, and many of the themes generated in this study map onto the existing literature.

Subjects reported a loss of audibility and intelligibility as a result of their hearing loss. Increases in mental energy were required to understand the message in a variety of situations. Some of these have been explored in the current investigations of listening effort. For instance, reverberant conditions were consistently reported as very difficult signals and environments for participants in this study. However, this is not consistent with previous data studying normal hearing participants, which demonstrates that reverberation is consistently not related to effort (Neumann, Wroblewski, Hajicek & Rubinstein, 2010; Picou, Gordon and Ricketts, 2015). This feasibly could occur because the effects of reverberation on listening effort may be different in populations with hearing loss. Furthermore, reverberation may interact with other factors of listening effort, such as intensity of the signal, size of the room, spatial situation & background noise levels. Additionally, increased intensity of the signal is another characteristic that was suggested to be beneficial for participants in this study. Conversely, signals of soft volumes were
reported to be difficult. As a variable, intensity volume has not been well explored in the literature. Subjects in this study also discussed other signals that have not currently been explored. These include accents, rate of speech, distorted speech, speaker age, and speakers who are discussing sensitive topics. Participants in this study presented several environments that are effortful to listen in. These include background noise and transportation noise, which have both been studied in the current literature (Picou, Ricketts & Hornsby, 2011; Koelewyn, Shinn-Cunningham, Zekveld & Kramer, 2014; Wu, Aksan, Rizzo, Stangl, Zhang, Bentler, 2014; Zekveld, Heslenfeld, Johnsrude, Versfeld & Kramer, 2014; Zekveld, Kramer & Festen, 2010) However, participants introduced several environments that affect listening effort which have not been systematically studied, which include situations where there are multiple talkers and conversation streams. Additionally, the effect of a conversation’s spatial arrangement on listening effort has not been explored.

It is clear that the allocation of extra energy toward challenging auditory signals has ramifications across many domains. Participants reported a number of methods to reduce listening effort, including anticipatory, repair, lifestyle and cognitive strategies. There seems to be a strong trend towards devices benefitting the listening effort experience, as measured objectively (Downs, 1982; Bentler & Duve, 2000; Hallgren, Larsby Lyxell & Arlinger, 2005; Hornsby, 2013) Hearing aid technologies such as noise reduction and directional microphones appear to have some benefit for at least some subjects in this study. This is consistent with the literature, which demonstrates that both technologies may or may not add additional benefits beyond standard amplification (Brons, Houben & Dreschler, 2012; Bentler, Wu, Kettel & Hurtig, 2008; Desjardins & Doherty, 2014; Desjardins, 2016; Kulkarni, Pandey, Jangamashetti, 2012; Picou, Aspell & Ricketts, 2014; Picou, Moore & Ricketts, 2017; Wu, Aksan, Rizzo, Stangl,
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Zhang & Bentler, 2014) However, data from this study suggests that assistive listening devices may be more beneficial than traditional amplification. However, there are no known studies that examine the effects of assistive listening devices on the listening effort experience. This finding may serve to introduce research questions that could benefit listeners with hearing loss who experience listening effort. Moreover, visual cues are used by some participants in this study. This is consistent with the literature, which show that the addition of visual cues has mixed results on the listening effort experience. (Fraser, Gagne, Alepins & Dubois, 2010; Picou, Ricketts & Hornsby, 2011). However, subjects discussed using a number of visual strategies that have not been studied in relation to listening effort, such as the usage of captioning on television or captioned telephones. Additionally, participants mentioned other types of strategies that are employed to understand the auditory message and reduce listening effort after a communication breakdown. Moreover, participants mentioned several lifestyle changes that alleviate the listening effort experienced every day. These types of repair and lifestyle strategies have not been investigated in relation to listening effort. Finally, according to participant interviews, cognitive strategies are employed during periods of listening effort. These cognitive strategies confirm current theories of listening effort as extra expenditures of cognitive energy in order to understand auditory messages.

Personal factors of listening effort were also found in this study, as motivation is an important moderating factor, which is consistent with the current literature (Picou & Ricketts, 2014). However, listening effort clearly has significant social and emotional impacts on patients with hearing loss. Exploration of social and emotional impacts of listening effort has not yet been undertaken. However, the current exploration in listening effort mainly focused on documenting
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and quantifying the amount of effort that are experienced in a variety of listening situations using a variety of measurement techniques.

This study documents reports of listening effort causing physical fatigue and stress. This relationship has been theoretically discussed in the current literature on listening effort (Bess & Hornsby, 2014; Hornsby, Naylor & Bess, 2016). However, much of the literature focuses on documenting the physiological effects of listening effort (Bertoli & Bodmer, 2014; Koelewijn, du Kluiver, Shinn-Cunningham, 2015; Koelewijn, Shinn-Cunningham, Zekveld, Kramer, 2014; Kramer, Kapteyn, Festen & Kuik, 1997; Kramer, Lorens, Coninx, Zekveld, Piotrowska, Skarzynski, 2013; Kramer, Teunissen & Zekveld, 2016; Kuchinsky, Allstrom, Vaden, Cute, Humes, Dubno & Eckert, 2013; Mackersie & Calderon-Moultrie, 2015; Mackersie & Cones, 2011; Mackersie, MacPhee & Heldt, 2015; Obleser & Kotz, 2011; Winn, Edwards, Litovsky, 2015; Wisniewski, 2016; Zekveld, Heslenfeld, Johnsrude, Versfeld & Kramer, 2014; Zekveld, Kramer, Festen, 2010). Participants did not report physiologic effects of listening effort such as these, however, they did report changes in respiration and temperature, as well as feelings of tension and pain.

From this study, it is clear extra effort is used to maintain vigilance, to advocate for hearing loss. However there are effortful byproducts of anticipating if advocacy will occur, and managing strategies to meet the needs of the individual. As such, listening effort is a collection of occurrences that happen regularly to an individual with hearing loss.

The five themes that were found most closely aligned with the FUEL model. These factors can be thought of variables that influence the effortful attention processes. The signal and environment that an individual is listening in can be considered as part of the source factors input- related demands on listening effort. Some mediating factors can also influence input
factors, like the use of amplification to effect the transmission of the signal. However, other mediating factors such as lifestyle strategies influence the overall state of the individual. For instance, fatigue can affect arousal levels, and individuals who go to sleep early in anticipation of an effortful listening experience the next day are directly influencing their own arousal level. Physical factors are likely part of the automatic arousal response to effort. Perhaps the most distantly related to the FUEL model is the personal factors finding. Surely, emotional effects are neurological in nature, and are associated with the listener factors of input-related demands. However, social impacts of listening effort often involve an interaction with another individual. Currently, there is no portion of the FUEL model of listening effort that involves a social component to the phenomena, but results of this study suggest that this is warranted.

**Limitations**

This study is not without limitations. First, despite attempts to recruit a wide sample into the study, the sample was a relatively homogenous population. Subjects tended to be females between the age of 65 and 74, who had advanced education and were employed. Furthermore, there were other aspects that were noted by participants but never reached saturation. These potential themes may have emerged if we had included a larger sample size that contained more diversity in the sample. These limitations mean that careful interpretations to theories drawn about the listening effort experience.

**Future studies of listening effort**

Future studies might include those with normal hearing to determine what at which point listening effort becomes problematic. Studies could also be completed with those that wear other hearing devices such as cochlear implants to determine aspects of listening effort for these
populations. Finally, studies could be completed with individuals across the age range to capture the developmental aspects contributing to the listening effort experience.

**Conclusion**

Ultimately, results of this study demonstrate the listening effort experience is a complicated and multifaceted experience. This study provides a patient centered account of variables affecting listening effort, and identifies several important themes. However, more investigation is clearly needed to understand contributing factors and underlying listening effort. Future studies should make a concerted effort to continue to include patients in experimental designs investigating the listening effort experience.
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Appendix A

IRB-1 Study Protocol

**Protocol Version # and/or Date:** Protocol Version 2, August 31, 2016.

**Study Protocol Title:** A qualitative examination of the listening effort experience of adults with hearing loss.

**Research Plan**

**Purpose/Introduction:** [State the reason for the study, the research hypothesis, and the goals of the proposed study as related to the research question(s). Provide a clear and succinct summary description of the background information that led to the plan for this project. Provide references as appropriate and, when applicable, previous work in animal and/or human studies. Provide previous UConn protocol number, if applicable.]

Listening effort is a phenomenon that many individuals with hearing loss experience in everyday communication and functioning. Anecdotal reports from persons with hearing loss document feelings of effortful listening and subsequent feelings of tiredness and fatigue (Bess & Hornsby 2014; Copithorne, 2006; Ross, 2007). Current exploration of listening effort is quantitative in nature, and tends to focus on specific aspects of the listening experience. Some of this work is being conducted on factors related to the signal of interest during the listening experience. Research on listening environments that are particularly difficult for listeners with hearing loss indicate that noise has negative consequences for accurate speech perception, which may increase listening effort (Picou, Gordon, & Ricketts, 2015). Much of this research is being conducted on factors related to the listening device. Investigations that follow this line of inquiry include work that examines how amplification decreases listening effort (Downs, 1982), and experiments that explore how directional microphones, noise reduction, or both can mediate listening effort (Hornsby, 2013; Desjardins & Doherty, 2014; Desjardins, 2016). Other research on listening effort examines how personal characteristics of the patient can mediate the experience with listening. Work in this domain includes exploration of perceived hearing difficulties (Hornsby & Kipp, 2015), as well as experiments examining personal coping strategies and motivational states that might mediate this experience (Picou & Ricketts, 2013).
In sum, there is a growing body of research that documents and explores various dimensions of listening effort. These are just some of the many attempts to explore the multitude of factors influencing listening effort, and work in this area is promising. However, there are other aspects that may contribute to the overall listening experience such as socio-cultural, identity, and personality differences that need to be explored for a more complete understanding of how listening effort.

Another issue with the current research is the dependence on quantitative and experimental methods, although there has been concerted effort to use both objective and subjective experimental designs. However, this is still problematic, as the relationship between subjective and objective indices of listening effort is unclear and the two measures can sometimes yield different results… Therefore, subjective and objective methodologies are both valuable measurement techniques, but the results from one study may not generalize to the other, and the two may in fact reflect two different constructs. (Picou, Gordon, & Ricketts 2015, p. 1)

Research that explores the characteristics of the experience of listening effort has yet to be conducted, as reflected in the lack of congruence between results using different methods. At this time, there is no clear stream of research with conclusive answers about the phenomena of listening effort that adequately tackles the range of variables that shape listening effort. Also lacking is a research thread that resolves the discrepancy between objective and subjective measures that supposedly target the same phenomena.

However, usage of qualitative research paradigms can address the issues with the current literature that prevent a holistic understanding of listening effort. First, semi-structured and open-ended interviews allow for a wider array of factors or themes to be explored as opposed to traditional quantitative paradigms. In order to have any statistical power, quantitative paradigms can only focus and control one, possibly two, aspects of listening effort. In interviews, many themes may emerge from an interview of a single patient. A more holistic understanding of listening effort will be reached through an interview paradigm. Furthermore, interviews allow for factors that haven’t yet been explored by quantitative paradigms to be explored. Quantitative paradigms carefully identify, isolate, and control the factors explored in a study as the study is designed. In contrast, qualitative paradigms allow for emergent themes to be explored, even when studies are initially conceptualized using a smaller set of factors and themes. As Knudsen et al. (2012) note:

- By… using an open-ended approach, qualitative research has the ability to generate new information that may otherwise have been overlooked. Focusing on the experiences and perceptions of people living with a health condition, qualitative methods recognize the uniqueness of the human experience. (p. 83)

By allowing multiple variables and perspectives, qualitative research can add to the understanding of listening effort within the greater context of the listening experience.
Secondly, qualitative research adds to a holistic understanding of the phenomena because when dovetailed with quantitative research, a more complete understanding of any variable can be reached.

The duality of two methodologies advancing scientific understanding is best demonstrated in a case study. In one such case study from the field of psychology, two investigations were completed documenting the attitudes and beliefs of therapists who became sexually attracted to their clients. One study applied a qualitative approach, and the other utilized a quantitative methodology. The qualitative study interviewed thirteen participants and transcribed the audio-recorded responses, whereas the quantitative study had 386 participants who answered a thirty item questionnaire, with twenty-two multiple choice and eight open response questions. Both studies found similar results in that the results covered similar themes. One such theme illustrated attributes of the therapy client that were especially attractive. The quantitative study documented that certain attributes such as attractiveness and vulnerability reached statistical significance. The qualitative study also found that these themes reached saturation, but the nature of the research added a descriptive element. The qualitative study had an element of experience in the data in including the description of a vulnerable patient as a man who’s fiancée had recently broken off their engagement. The consumer of this research understands and can now access the data more readily with this description in mind. The expressive nature of qualitative work is especially critical in the study of a relatively unknown phenomena such as listening effort which has previously only been studied with quantitative research. When combined with quantitative work, qualitative work will add a descriptive element to the research that will help for the understanding of listening effort and the listening experience. (Ladany, N., O’Brien, K., Hill, C., Melincoff, D., Knox, S., Petersen, D., 1997; Roldofa, E., Hall, T., Holms, V., Davena, A., Komatz, D., Antunez, M., Hall, A., 1994)

There is a third reason why qualitative research should be used to study the phenomena of listening effort and the listening experience. Interviews give patients and research participants an opportunity and a voice with which to speak about their experiences with listening effort, which is lacking in the current literature. At the present, investigators drive research. Even when research is subjective, and aims to elicit the patient’s perspective, survey items (like the Speech, Spatial and Qualities of Hearing Questionnaire) are generated by investigators (Gatehouse & Noble, 2004). Because listening effort is such a highly personal experience, it is important to gather evidence from the patient perspective. This characteristic of qualitative work aligns well with the movement toward patient-centered care, with the argument being that “patient-centered clinical method as one in which the physician aims to gain an understanding of the patient as well as the disease- as opposed to an approach focusing strictly on the disease” (Levenstein, 1986). There are many benefits to a patient-centered interview such as:

- approaching the patient as an unique human being with his own story to tell, promoting trust and confidence, clarifying and characterizing the patient’s symptoms and concerns, generating and testing many hypotheses that may include biological and psychosocial dimensions of illness, and creating the basis for an ongoing relationship (Lipkin et al., 1984, p. 277)
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To use interview in understanding the phenomena of listening effort would lead to an understanding of the disorder from the patient perspective, which could contribute to patient-centered care of listening effort in the clinic.

In conclusion, there are at least three reasons as to why interpretive methods, specifically interviews, would be beneficial for the study of listening effort. These include exploration of factors that pertain to listening effort that have not or cannot be studied using quantitative paradigms, gaining a holistic understanding of listening effort, and a patient-centered understanding of the phenomena. Thus, the goal of this project is to investigate listening effort and the overall listening experience of adults with hearing loss using qualitative methodology.

Design, Procedures, Materials and Methods: [Describe the study design, including the sequence and timing of all study procedures. Include screening procedures, if any. The IRB strongly suggests that investigators incorporate flexibility into the study design to accommodate anticipated events (i.e. explain how missed study appointments can be made up by participants). If the research involves study of existing samples/records, describe how authorization to access samples/records will be obtained. If the study involves use of deception explain the reason why this is necessary. If applicable, describe the use of audiotape and/or videotape and provide justification for use. If this study offers treatment for the participants’ condition, complete the Treatment Study Supplemental Form (IRB-1C) and attach it to this application for review. If the study includes measures, survey instruments and questionnaires, identify each and, if available, provide references for the measures. Describe what they intend to measure (relate to purpose/hypothesis) and their psychometric properties (e.g., reliability and validity). Identify any that were specifically created for the study.]

Participants will be given an explanation of the study and given time to read the consent form. They will be told that the study is made up of two portions- the interview, which they are participating in, and a review portion. Participants will be told that unless they opt out, they will be contacted at a later date inviting participation in part two of this study, which will consist of a review of the preliminary data. They can opt in, which gives permission to be contacted at a later date, or opt out, which removes permission for contact for part two of the study.

Participants will be asked to take part in a study of listening effort and the overall listening experience of adults with hearing loss by participating in interview. Participants will be scheduled for a two-hour session in which they will complete an intake form as well as a semi-structured interview. The intake form consists of basic demographic questions and is based off of an intake form used in qualitative audiologic research conducted by Laplante-Levesque et al. (2011). This can be found in Appendix A.

Prior to beginning the second phase of testing, participants will either provide a copy of a recent hearing test completed within 1 year of the experiment, or will undergo an unaided hearing screening completed with a portable audiometer. Participants will also complete the Hearing Handicap Inventory, either the adult version, or the elderly version- whichever is more
appropriate for their age (Ventry & Weinstein, 1982; Newman, Weinstein, Jacobsen & Hug, 1991). This can be found in Appendix B. As it has been shown that perceived hearing difficulties can influence subjective ratings of fatigue, it is pertinent to assess the audiometric and perceived hearing difficulties of the participants (Hornsby & Kipp, 2015). Both the audiometric and subjective measures will be used for categorization purposes during data collection, which will enlighten the responses in the interview phase of the study.

The majority of the session will be spent completing the interview, using a semi-structured interview protocol. Semi-structured interview asks general open-ended probes that invite the interviewee to describe and define their personal experiences in a conversational manner. (Fylan, 2005) The interview will continue until the probe list has been completed, and the participant feels they no longer has any other relevant comments. Should the interview process go beyond a three-hour time frame, a second interview will be scheduled for another time in order to prevent participant fatigue.

The process of this exploration of listening effort as it relates to the listening experience is of an inductive nature. Content areas based on the existing literature on listening effort have been generated. These areas are factors that mediate the listening experience and are: cognitive factors, bodily factors, device factors and personal factors. The interview topics will cover the listening experience and target these content areas related to issues of listening effort. Probes can be found in Appendix C.

The interview will be video-recorded and transcribed in order to conduct qualitative content analysis. Transcription will include a verbatim record of what was said during the interview, as well as any body language, expression and gesture. It is for this reason video recording must be utilized, as it is critical to document the spoken content, but also to capture any visual language that can contribute to the message being delivered. Only the interview portion of the study will be recorded.

**Justification of Sample Size/Data Analysis:** [Justification of Sample Size: For qualitative and pilot studies, describe how the proposed sample size is appropriate for achieving the anticipated results. For quantitative studies, provide a power analysis that includes effect size, power and level of significance with references for how the sample size was determined. Explain the rate of attrition, with references as appropriate. Data Analysis: For all studies, provide a description of the statistical or qualitative methods used to analyze the data.]

Recruitment will be conducted according to maximum variation sampling (Sandelowski, 1995) in order to capture a broad range of experiences with listening effort among adults with hearing impairment. Data collection will continue until there are enough variations in the sample with regards to the major areas of the listening experience. For example, an attempt will be made to recruit adults using a variety of different hearing aid companies to ensure a variation across
device factors are well represented. Based on previous qualitative research in this area, it is expected that maximum variation sampling will yield saturation around 15 to 20 participants, however, it is possible that saturation can be reached with more or fewer participants. The total N will be 40.

To facilitate transcription, coding, and analysis of the data, this project will use NVivo software, which is designed to help organize and facilitate qualitative research. Participant names will not be entered into the software, nor will be mentioned in the interview in order to maintain as much confidentiality as possible.

The interview transcripts will be coded using qualitative content analysis. Qualitative content analysis has been used in other health research (Elo & Kyngas, 2007). Qualitative content analysis is a means of text analysis via information processing schemes (Bos, 1999). Coding is a process by which meaning is extracted from the text via a series of codes, which are systematically organized to extract meaning. The smallest unit is a code, which is “a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language- based… data” (Saldana, 2013, p. 3). Codes are then organized into sub-categories, categories, and then overarching themes (Graneheim & Lundman, 2003). Once themes have been found, they can be used to explain social reality (Bos, 1999). In this instance, themes will explain how listening effort influences the listening experience.

Three methods of establishing credibility that have been used in audiologic qualitative research will be employed in this study. First, triangulation will occur between three reviewers, one of whom is the student researcher. The student researcher will do the initial code of the data, and two secondary reviewers who are not present at the time of the interview will access the interview transcripts and code the data separately in order to avoid bias. Checks of inter-rater reliability will be performed, and discrepancies between codes will be discussed and resolved. This is one method to obtain credibility that has been utilized in audiologic qualitative research (Hallberg & Carlson, 1991).

Secondly, at the end of data analysis, a random subset of participants who indicated availability and interest will be selected to read a summary of the main findings of the analysis, and will be asked to comment on findings. Readers will be asked to confirm or reiterate ideas found in data analysis. The use of member checking will be another method utilized to build credibility, and it has a tradition of use in audiologic qualitative work (Scarinci, Worrall & Hickson, 2008).

The final method to establish credibility will include the documentation of field notes on nuances and impressions from the interviews directly after the interviews. This journaling will be utilized to help support the interpretation of the interview meanings. This process can also address and document the interviewer’s subjectivities so that the research process can avoid including as much unconscious subjectivity as possible. This process has also been used to reach credibility in audiologic research (Lockey, Jennings & Shaw, 2010).
**Inclusion/Exclusion Criteria:** [List major inclusion and exclusion criteria. Any proposed exclusion criterion based on gender (women of childbearing potential), age, or race must include justification for the exclusion. Describe the conditions under which participants may be removed from the study, i.e., noncompliance with study rules, study termination, etc.]

All participants over 18 with hearing aids will be included in this study. All participants over 18 with hearing aids will be included in this study. Participants must utilize spoken communication as their primary communication modality. Participants may utilize other forms of communication (manual communication-ex: American Sign Language, Signed English Systems), however the one that they communicate with most often must be spoken communication.

Participants who utilize alternate communication modalities as their primary communication method will be excluded from participating in the study. Participants will be excluded from participating in the study if they do not own hearing aids. Those who have hearing loss but do not utilize amplification, utilize Cochlear Implant, BAHA, or technology other than traditional hearing aids will not be included. Participants must be older than 18.

**Risks and Inconveniences:** [Describe the potential risks to participants (and secondary participants, if applicable) and steps taken to minimize risks. Assess the likelihood of the risk occurring and, if it were to occur, the seriousness to the participant. Types of risks to consider include: physical, psychological, social, legal, employment, and financial. Also describe any anticipated inconveniences the participants may experience (time, abstention from food, etc.).]

One risk to the participant is that the interview may discuss topics of a personal nature. The questions are not designed to be probing, but due to the semi-structured nature of the interview, intimate topics may arise. Participants will be allowed to decline to answer any question they wish to. Participants can also choose to stop the interview at any time, whether they are physically or emotionally fatigued.

One inconvenience is the time needed to complete this task. This is estimated to be approximately 2 hours, although it can vary widely depending on the richness of the interviewee responses. Individual data collection sessions will not last longer than 2 to 3 hours, and if a session appears to need more time, subsequent data collection sessions will be schedule to prevent interviewee fatigue. If a participant appears to fatigue earlier than the 3 hour session, another session will be scheduled at a time that is mutually convenient.

**Benefits:** [Describe anticipated benefits to the individual participants. If individual participants may not benefit directly, state so here. Describe anticipated benefits to society (i.e.,]
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added knowledge to the field of study) or a specific class of individuals (i.e., athletes or autistic children). Do not include compensation or earned course credits in this section.

There are definite potential benefits for the participant, including an opportunity to discuss a topic that is currently not being adequately addressed in traditional audiologic practice. Participants may learn about a phenomena that they have experienced but did not have a label to describe. Participants will be able to explore their own listening experiences in an empathetic, supportive environment. Participants may gain greater insights into the nature of their own hearing impairment through the interview process.

**Risk/Benefit Analysis:** [Describe the ratio of risks to benefits. Risks to research participants should be justified by the anticipated benefits to the participants or society. Provide your assessment of anticipated risks to participants and steps taken to minimize these risks, balanced against anticipated benefits to the individual or to society.]

It is thought that the benefits of this study outweigh the risk, as there are counter measures to prevent the inconveniences that may occur, and the magnitude of the potential benefit outweighs the risk.

**Economic Considerations:** [Describe any costs to the participants or amount and method of compensation that will be given to them. Describe how you arrived at the amount and the plan for compensation; if it will be prorated, please provide the breakdown. Experimental or extra course credit should be considered an economic consideration and included in this section. Indicate when participants will receive compensation.]

There are no economic considerations for this study, as it is an unfunded project.

**Data Safety Monitoring:** [This is a prospective plan set up by the study investigators to assure that adverse events occurring during studies are identified, evaluated, and communicated to the IRB in a timely manner. Although the investigators initially propose a Data Safety Monitoring Plan (DSMP), the IRB must approve the plan and may require revision of the plan. A DSMP is required for all human studies at the University of Connecticut except for studies determined to be exempt from continuing IRB review. For studies that present more than minimal risk to participants, the IRB will review and determine on a case-by-case basis whether a data safety monitoring board is most appropriate. Please refer to the IRB’s policy regarding data safety monitoring before completing this section - [http://research.uconn.edu/policies-procedures](http://research.uconn.edu/policies-procedures).

Issues that should be addressed in the DSMP include the following:

1. frequency of the monitoring
2. who will conduct the monitoring (Under UConn policy a student cannot be the sole person responsible for monitoring the data and safety of the protocol procedures.)
3. what data will be monitored
4. how the data will be evaluated for problems
5. what actions will be taken upon the occurrence of specific events or end points
6. who will communicate to the IRB and how communication will occur]
Interview results will be monitored by the PI in conjunction with the student investigator once every two weeks (items 1, 2 and 3). Interview responses will be reviewed to monitor for clarity (i.e., the same question is left unanswered or skipped by 8 or more participants). In that case, the question will be revised and an amendment will be submitted to the IRB (items 4, 5 and 6).

**Privacy/Confidentiality:** [Explain how the privacy interests of participants will be maintained during the study (note that privacy pertains to the individual not to the data). Describe procedures for protecting confidentiality of data collected during the study and stored after study closure. Describe how data will be coded. Describe plans for storage and security of electronic data (plan must comply with the University’s Policy on the Security Requirements for Protecting University Data at Rest). If identifiable, sensitive information (illegal drug use, criminal activity, etc.) will be collected, state whether a Certificate of Confidentiality will be obtained. Be sure to state whether any limits to confidentiality exist and identify any external agencies (study sponsor, FDA, etc.) that will have access to the data. If participants will be screened, describe the plans for storage or destruction of identifiable data for those that failed the screening.]

Privacy of the individual will be established by conducting the study in an agreed upon meeting location that quiet and away from individuals who may overhear personal information.

All survey and audiometric information will be collected without identifying information and use a code in place of identifying information. This code, which will be derived from a sequential three digit code that reflects how many people have enrolled in this study. Transcription and data analysis will utilize the same code as well.

Researchers will keep all study records, including any codes to data locked in as secure location. Video will be collected on an iPad, and immediately downloaded to a secure computer in the Aural Rehabilitation Laboratory, then deleted from the iPad. All data transcription will occur by members of the research team. No one else will view the tapes, nor will they be used for purposes other than the transcription process. Transcribed interviews will be viewed by members of the research team, and will also be stored in a secure location. Study records will be kept for three years in the locked Aural Rehabilitation Lab. Only Aural Rehabilitation Laboratory members will have access to these records.
References / Literature Review:


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Informed Consent

As PI, you are responsible for taking reasonable steps to assure that the participants in this study are fully informed about and understand the study. Even if you are not targeting participants from “Special Populations” as listed on page 4, such populations may be included in recruitment efforts. Please keep this in mind as you design the Consent Process and provide the information requested in this section.

Consent Setting: [Describe the consent process including who will obtain consent, where and when will it be obtained, and how much time participants will have to make a decision. Describe how the privacy of the participants will be maintained throughout the consent process. State whether an assessment of consent materials will be conducted to assure that participants understand the information (may be warranted in studies with complicated study procedures, those that require extensive time commitments or those that expose participants to greater than minimal risk).]

The student researcher will obtain consent from the subject. It will be obtained prior to the beginning of the study. The participants will have as long as they like to make a decision
regarding consent. Privacy of the individuals will be assured by obtaining the consent in the study location, which will be quiet and away from other individuals who may overhear. Participants will be asked if they understand the consent form before they sign consent.

**Capacity to Consent:** [Describe how the capacity to consent will be assessed for participants with limited decision-making capacity, language barriers or hearing difficulty. If a participant is incapable of providing consent, you will need to obtain consent from the participant’s legal guardian (please see the IRB website for additional information).]

Participants in this study will be adults who have hearing loss, so a written copy of the consent will be provided in order to ensure the participants understand and have the capacity to consent.

**Parent/Guardian Permission and Assent:** [If enrolling children, state how many parents/guardians will provide permission, whether the child’s assent will be obtained and if assent will be written or oral. Provide a copy of the script to be used if oral assent will be obtained.]

N/A

**Documentation of Consent:** [Specify the forms that will be used for each participant population, i.e., adult consent form, surrogate consent form, child assent form (written form or oral script) or an information sheet. Copies of all forms should be attached to this application in the same format that they will be given to participants (templates and instructions are available on the IRB website).]

An adult consent form will be used for the participant population. Video release form is not necessary, as the video will not be used for anything other than data transcription. Please see the copy of the consent form.

**Waiver or Alteration of Consent:** [The IRB may waive or alter the elements of consent in some minimal risks studies. If you plan to request either a waiver of consent (i.e., participants will not be asked to give consent), an alteration of consent (e.g., deception) or a waiver of signed consent (i.e., participants will give consent after reading an information sheet), please answer the following questions using specific information from the study:]

N/A

Waiver (i.e. participants will not be asked to give consent) or alteration of consent (e.g. use of deception in research):

- Why is the study considered to be minimal risk?
How will the waiver affect the participants’ rights and welfare? The IRB must find that participants’ rights are not adversely affected. For example, participants may choose not to answer any questions they do not want to answer and they may stop their participation in the research at any time.

Why would the research be impracticable without the waiver? For studies that involve deception, explain how the research could not be done if participants know the full purpose of the study.

How will important information be returned to the participants, if appropriate? For studies that involve deception, indicate that participants will be debriefed and that the researchers will be available in case participants have questions.

Waiver of signed consent (i.e. participants give consent only after reading an information sheet):

Why is the study considered to be minimal risk?

Does a breach of confidentiality constitute the principal risk to participants? Relate this to the risks associated with a breach of confidentiality and indicate how risks will be minimized because of the waiver of signed consent.

Would the signed consent form be the only record linking the participant to the research? Relate this to the procedures to protect privacy/confidentiality.

Does the research include any activities that would require signed consent in a non-research setting? For example, in non-research settings, normally there is no requirement for written consent for completion of questionnaires.
Introduction

You are invited to participate in a research study to investigate listening effort and the overall listening experience of adults with hearing loss. You are being asked to participate because you are an adult with hearing loss who utilizes hearing aids.

Why is this study being done?

We are conducting this research study to interview individuals with hearing loss who have experienced listening effort to add to the current understanding of listening effort.

What are the study procedures? What will I be asked to do?

There are two parts to the research study. In the first part you will be asked to complete an intake questionnaire reporting demographic information. You will also complete a survey asking questions about your social and emotional experiences with hearing loss. You will also complete an unaided hearing screening. If you have audiologic test results from your audiologist dated within one year, this test will be accepted and you do not have to complete screening. The survey
and the hearing screening will only be used for categorization in the data analysis phase of this study.

The second portion of this research project consists of an interview. You will be asked several open-ended questions asking you to discuss various aspects of your listening experience. The topics covered range from describing listening effort, the time course of listening experience, social aspects of listening effort, cultural influences of listening effort, emotional impacts of listening effort, and physical ramifications of listening effort.

The interview portion of the study will be videotaped. The purpose of the videotaping is to have an audio transcription of your answers, but also to provide access to any visual language that is presented (facial expressions, gestures, etc.). The video tape will not be viewed by anyone other than the primary interviewer, and two secondary interviewers. The video tape will be stored in a secure location.

The research will be conducted in a quiet environment that is mutually convenient for you and the interviewer. It will also occur at a time and date that is mutually convenient for you and the interviewer. Data collection should not exceed two to three hours, but if needed, a second data collection session will be scheduled at another mutually convenient date and time.

If you are interested, we may contact you in the future to participate in another portion of the study, where you will have an opportunity to read our preliminary findings and provide feedback. If you are interested, we will use your preferred mode of communication (phone or email) to reach out to you after preliminary analysis is complete.

What are the risks or inconveniences of the study?

One risk is that the interview may discuss topics of a personal nature. The questions are not designed to be probing, but due to the semi-structured nature of the interview, intimate topics may arise. You will be in a supportive, empathetic environment while you are answering questions. You do not have to talk about topics you do not wish to. You will be allowed to decline to answer any question they wish to. You can also choose to stop the interview at any time, whether you are physically or emotionally fatigued.
One inconvenience is the time needed to complete this task. This is estimated to be approximately 2 hours, although it can vary widely depending on the richness of your responses. Individual data collection sessions will not last longer than two to three hours, and if a session appears to need more time, subsequent data collection sessions will be scheduled to prevent interviewee fatigue. If you appear to fatigue earlier than the three hour session, another session will be scheduled at a time that is mutually convenient.

What are the benefits of the study?

There are definite potential benefits for the participant, including an opportunity to discuss a topic that is currently not being adequately addressed in traditional audiologic practice. You may learn about a phenomena that you have experienced but did not have a label to describe. You will be able to explore your own listening experiences in an empathetic, supportive environment. You may gain greater insights into the nature of their own hearing impairment through the interview process. You will also be contributing to research that will help further the understanding of listening effort, which will help both the field of audiology and society in general.

Will I receive payment for participation? Are there costs to participate?

There are no costs and you will not be paid to be in this study.

How will my personal information be protected?

All survey and audiometric information will be collected without identifying information and use a code in place of identifying information. This code, which will be derived from a sequential three digit code that reflects how many people have enrolled in this study.

Researchers will keep all study records, including any codes to your data locked in as secure location. Video will be collected on an iPad, and immediately downloaded to a secure computer in the Aural Rehabilitation Laboratory, then deleted from the iPad. All data transcription will occur by members of the research team. No one else will view your tapes, nor will they be used for purposes other than the transcription process. Transcribed interviews will be viewed by members of the research team, and will also be stored in a secure location.
Study records will be kept for three years in the locked Aural Rehabilitation Lab. Only Aural Rehabilitation Laboratory members will have access to these records.

We will do our best to protect the confidentiality of the information we gather from you but we cannot guarantee 100% confidentiality.

You should also know that the UConn Institutional Review Board (IRB) and Research Compliance Services may inspect study records as part of its auditing program, but these reviews will only focus on the researchers and not on your responses or involvement. The IRB is a group of people who review research studies to protect the rights and welfare of research participants.

Can I stop being in the study and what are my rights?

You do not have to be in this study if you do not want to. If you agree to be in the study, but later change your mind, you may drop out at any time. There are no penalties or consequences of any kind if you decide that you do not want to participate. During the interview portion, you may also stop at any portion, and you also do not have to answer any question that you do not want to answer.

Whom do I contact if I have questions about the study?

Take as long as you like before you make a decision. We will be happy to answer any question you have about this study. If you have further questions about this study or if you have a research-related problem, you may contact the principal investigator, Kathleen Cienkowski at 860-486-1043 or the student researcher Alison Marinelli at 860-486-1043. If you have any questions concerning your rights as a research participant, you may contact the University of Connecticut Institutional Review Board (IRB) at 860-486-8802.

Documentation of Consent:

I have read this form and decided that I will participate in the project described above. Its general purposes, the particulars of involvement and possible risks and inconveniences have been explained to my satisfaction. I understand that I can withdraw at any time. My signature also indicates that I have received a copy of this consent form.
Appendix B: Interview prompts

Initial prompt

- Have you had this experience of feeling like listening to someone requires effort? Can you tell me about it? How would you explain it to someone who does not suffer from hearing loss?
- In which situations do you feel increased listening effort?

Other prompts

- Sometimes it is easier to talk about specific instances. Can you recall a particular occasion on which you felt increased listening effort? Can you tell me about that?
  - Who were you talking to?
  - What was the context of the conversation?
  - What did the environment look like? Sound like?
  - What were you doing?
  - How were you feeling emotionally?
  - How were you feeling physically?
  - What were you thinking about?
- Has there ever been a time when listening effort was actually a good thing?
- Has there ever been a time when listening effort was a bad thing?
- Mediating Factors: Does anything make listening effort better or worse?
  - Example if needed: Background noise? Distance? Reverberation?
  - Does your hearing aid help you with listening effort?
  - Do you ever switch programs to help with listening effort or difficult listening situations?
  - Are there other devices that you use that help with listening effort?
  - Are there strategies that you utilize that help with listening effort?
- Does listening effort affect you at work?
  - What is your work environment like? Is your job demanding? Do you have any control on the job?
  - Do you need to rest and recover after work?
- Does listening effort affect you at home or with your friends? In what ways?
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- Are these experiences at home and at work similar or different?

- Timecourse of listening effort
  - When did you first notice your hearing loss?
  - When did you first experience listening effort?
  - Do you experience LE more now or when you first noticed HL?

- Have you had interactions with other people with hearing loss?
  - Do they seem to experience listening effort in the same way that you do?
    - Do you have any sense of why?
  - Do people without hearing loss seem to experience listening effort in the same way that you do?
    - Do they seem to understand your experience with listening effort?

- Do you consider yourself to be a communicatively active person?
  - How much of your day is spent communicating?
  - With whom do you communicate?
  - Where do you communicate?

- How do you perceive your hearing loss?

- Cultural influences & listening experience
  - Do you think your culture influence the way you perceive your hearing loss?
    - Perception of listening effort?

- Emotional impacts & listening experience
  - Are there emotional impacts of your hearing loss?
    - Emotional impacts of listening effort?
  - Does your HL or experiences with listening effort impact your confidence?
  - Does your HL or experiences with listening effort impact feelings self-esteem?
  - Does your HL or experiences with listening effort impact feelings of self-efficacy?
  - Does your HL or experiences with listening effort impact general emotional well-being?
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- Does your personality impact how you manage your hearing loss? Or does your hearing loss impact your personality?
- Would you say you’re a motivated person? Does that affect your listening experience?

- Social functioning & listening experience
  - Has your social ability been reduced by your hearing loss and your experiences with listening effort?
  - Has your hearing loss and experiences with listening effort impacted relationships in your life?

- Physical ramifications & listening experience
  - Are you fatigued as a result of your hearing loss?
    - Physically?
    - Emotionally?
    - Mentally?
  - Do you have reduced vigor as a result of your hearing loss?
  - Do you ever experience physical sensations like a headache or a stomachache at the end of a period of listening effort?
  - Does listening effort cause you stress and tension?
  - Do you use visual cues to mediate listening effort?

Appendix C: Debriefing Questions

Response to Transcript

1. What was your initial reaction to re-reading the transcript?
2. Is there anything you would like to clarify or change in this transcript?

3. Have any of your thoughts or opinions changed since you were first interviewed? If they have, how so?

4. In your opinion, what are the most important aspects of this interview?
Appendix D: Subjectivity Statement

It seems this project has been a long time coming. Events had to happen just so in order to build the storm of questions that drove this dissertation. This is the story of how it came to be, and how I, for better and for worse, shaped this project.

Every methodological appendix written by the authors of qualitative research attempts to discuss his or her own values and beliefs that may have influenced the research. Laying bare these essential truths, serves a dual purpose. Firstly, it is important for the researcher to examine her own experience with a polished lens. This process of revisiting memories with a specific qualitative exploration in mind grinds away the unnecessary and unwanted impurities that distort the findings. The methodological appendices serves as a pair of new glasses: when worn, a less myopic version of the truth becomes clear. And second, readers of the completed work – by reviewing the researcher’s subjectivity – can decide for themselves how the author’s identity shaped the conclusions rendered. It is a chance to figuratively borrow the glasses the author has worn. Ultimately, the reader too has their own biases, but donning the glasses of the researcher -- and looking around -- may help them understand more about this project and its conclusions.

Here I present my subjectivities, discussing both what I brought to this project, and what I took from it. In polishing my glasses, I turn them over to the reader.

What came before

There were patterns building to this project before I became an audiologist, before I was born. Compared to the fields of medicine and human psychology, audiology is a relative newcomer, as it was formed as a response to veterans returning from World War II. New weapons technologies had left many with injuries, and some suffered from service-connected
noise-induced hearing loss. Many founding scientists of audiology studied sensory psychology. These early professionals used their understanding of newly developed theories of attention and information processing and worked with speech and language pathologists and teachers of the deaf to rehabilitate soldiers returning with significant noise induced hearing loss.

Rudimentary amplification existed during this time, although its use was not widespread. Hearing aid and cochlear implant technology developed rapidly in the 1970s and 1980s with the invention of microprocessor computers. In 1990, the Americans with Disabilities Act was signed by George H.W. Bush and afforded thousands of individuals with special needs rights and protections that previously did not exist in the U.S. Cochlear implantation for children was approved by the FDA in 1992. Finally, newborn hearing screenings were not commonplace in the U.S. until the mid 90s.

Audiologic research shifted towards developing sensitive and specific tests to quantify hearing loss. Research continued in the same manner, as the predecessors in psychology did, with quantitative experimentology driving investigations. Because of this, patients voices were seldom systematically included in audiolologic research, with a few notable exceptions (Hallberg & Carlsson, 1990; Laplante-Lévesque, Hickson & Worrall, 2010a; Laplante-Lévesque, Hickson & Worrall, 2010b; Laplante-Lévesque, Knudsen, Preminger, Jones, Nielsen, Öberg, Lunner, Hickson, Naylor & Kramer, 2011; Lockey, Jennings & Shaw, 2010; Scarinci, Worrall & Hickson, 2008; Southall, Gagné & Jennings, 2010). A rather recent phenomena, qualitative and interpretive research has been used to explore various aspects of the patient experience.

How I came to be
The scene was set for a young child with hearing loss to rise to a level of relative success, but small miracles still had to occur. I was born in 1990, the same year ADA was signed, but before newborn hearing screenings were commonplace. I was not screened in the hospital, but my mother insisted that I receive a hearing test at five months. That meant that my eventual diagnosis at nine months occurred a full 26 months before the average child with hearing loss was diagnosed. In the days before newborn hearing screenings were standard hospital procedure, children with hearing loss were often not diagnosed until two or three years of age, when an lack of expressive communication became obvious.

Because I was fit with hearing aids earlier than two or three, I had access to auditory development relatively early. Moreover, I was implanted two years after the procedure was approved for children. I wasn’t the first child to be implanted, but generally speaking, I was certainly among the first. It took a major leap of faith for my parents to consent to putting their barely four year old child under anesthesia for a medical procedure that warranted a three-day hospital stay. The cochlear implant worked remarkably well, when it came time to consider enrollment into school that September, it was suggested that I had learned so much in the one year I was implanted that I’d be bored in kindergarten. So I, along with my one year old ear, and the stuffed goat from Esmerelda, I boarded the bus for the first grade. Small miracles indeed.

My mother tells me that she suspected problems with my hearing very early on. I was one of three cousins born in the same year and they seemed to notice sounds in their environment in ways I never did. I slept through thunderstorms and our big dog Riley barking at strangers outside the door. I was rarely startled at noise. She says she mentioned it to the doctor who tried to assuage her fears. However, she persisted in demanding a hearing test after an experience where she tried unsuccessfully to get my attention. The story goes, that one day I was put down
in the crib for a nap at my grandmother’s house and some time later, I woke up crying. I was facing away from the door, playing with toy spinners attached to the side of the crib. She called my name, and I did not turn. She tried again, and I did not turn. She yelled for my father to come, yelled for my grandmother to come, I did not stop crying and I did not turn. My father rushed in, and still I did not turn. My grandmother came after him, I did not turn. They all shouted, and I did not stop fussing, or playing. They brought in pots and pans to bang together and created what must have been a royal ruckus and I still didn’t stop playing with the toys, stop fussing, or turn around.

My mother succeeded in getting a hearing test. The first test was at Saint Francis Hospital in Hartford, and my mother tells me that after testing for a while, the audiologists told my parents they couldn’t get results due to faulty equipment. They asked her to return to the hospital another day to obtain results. The appointed day was a day that my father had a photography shoot scheduled, so she’d have to come alone. My parents left the office and walked a short way down the hall before an audiologist came running after them. “The equipment was working,” she said, “Come back and we’ll look for results.” When my mom recalled this memory to me, she commented, with a sad smile, that the audiologist probably suspected I was deaf. She probably brought them back in because didn’t want to tell her the news of my hearing loss at the next appointment when my mother was by herself.

My mother’s persistence meant that I was diagnosed with a moderately severe hearing loss at 9 months and was fit with Oticon E380 power hearing aids by 11 months. Growing up, I was privy to some of the best parents, audiologists, speech and language pathologists, aural rehabilitationists, teachers of the deaf, general educators, and administrators. Some of this is by virtue of being born and raised in a geographically tolerable climate; therapy appointments were
never more than 45 minutes away. However, some was due to the fact that I happened to be born to these parents, who understood the hard work it would take to help a deaf baby hear, and were prepared to learn the lessons birth to three providers and early interventionists instilled in them.

My mother recently gave me a bag stuffed with all of the materials she used to teach me to speak: binders of hand colored pictures of different /p/, /m/, & /b/ sounds - pig, peaches, man, mask, balloon, basket, bed; a photo book outlining a day-in-the-life with carefully written sentences describing how I get ready in the morning, how I eat lunch, how I play with the dollhouse, how I play on the swings, how Daddy picks me up from daycare.

And there were old home videos showing the walls of our house decorated with educational posters about colors, shapes, letters of the alphabet and other vocabulary enrichment opportunities. My parents’ disembodied voices can be heard throughout, constantly talking to me, barraging me with questions, providing answers to my questions, and actively engaging me into the world. Rewatching these memories with my family is amusing. My father turned to my fiancé and explained, “We had to talk to her like that so she could learn language.” I remember Danny nodding solemnly; it was the first time he had seen me as anything other than I am now.

The linguistic differences between myself at 4 years of age and my younger, hearing sister at 4 years of age were night and day. With my parents’ help, I made rapid progress, and those early language experiences that were afforded to me by my parents is irreplaceable. I still have early interventionists come up to me 25 years later and tell me that my mother was the best they’ve worked with in their entire career. On the car ride home after watching the home videos, Danny turned to me, smiled, and matter of factly pointed out that I still make the same cute face when I don’t hear something. I laughed. It’s a good thing he thinks it’s adorable, because it’s never going away.
The hearing loss may be genetic, but my parents did their best to help me overcome negative barriers and reach a level of positive self-acceptance. Along with two other parents of deaf children in town, they fought the public school system to provide a teacher of the deaf. Nancy Simison came into my life in the second grade, and she followed me through to the high school. She, with my parents, taught me how to self-advocate from an early age. As young as third grade, I was taught how to request an accommodation from a teacher. We would practice what to say, and role-played until I felt comfortable. In the early days, Nancy would take my hand and stand beside me, and I felt her support throughout my public school education, even when she wasn’t in the room.

My parents also drove me to my many audiology appointments, going wherever it was necessary to receive a quality program. This meant sometimes we would go as far away as New York City, sometimes to Hartford, and then to East Hampton when the New England Center for Hearing Rehabilitation opened. Again, it was these professionals who monitored my progress, maintained my equipment, and worked to train my second cochlear implant once I received it. My audiologist, Kristin, and my speech therapist, Diane, worked to improve my speech perception abilities over the course of my lifetime, and I still work with them to this day.

I decided to pursue a degree in audiology because I recognized the beneficial impact that a positive support system has on a child with hearing loss. After exploring several job opportunities, I decided that speech and language pathology or audiology would be the best career opportunities to fulfill the desire of helping the opportunities I was privileged to have become mainstream practice for children with hearing loss. Even so, I took my early experiences for granted. It was only until graduate school that I gained a healthy sense of objectivity. In examining the reality that was pre-lingual deafness in the early 90s, it became clear that my
experiences are extraordinary. Inadvertently, Dr. Mark Ross helped me to come to this conclusion. His life’s perspective, written in the Journal of the Academy of Rehabilitation Audiology & on the Rehabilitation Engineering Research Center website, shows how far we’ve come in just a short amount of time, and also how lucky I was to be born in the time that I was. As a field, we can bring the opportunities I was afforded to others less lucky.

One evening, I was sitting in a board meeting for a local hearing loss association of America chapter specifically for pre-teens, teens, and young adults with hearing loss. I embarrassed myself because the board was talking about how to improve the individualized education plans (IEP) that are regularly formulated by teachers for children with hearing loss in the state of Connecticut. I explained that, as a student, I ran my own IEP meetings, and suggested that we work to empower students to do the same. The board immediately responded with comments stating that I was a “special case” and that not everyone could run such a meeting. I defended my position, arguing for the use of scripts to guide the meetings and allow students with hearing loss some agency. I recognized not everyone had the same supports I did, but we should want to constantly hold our students to a higher standard, and strive to provide similar supports.

I’ve grown tired of being told I am an exceptional deaf young adult. I’m not. But I have been privileged to have the experiences I have been afforded. And these are experiences that we can provide for all individuals with hearing loss. But barriers exist, including a lack of access to amplification and aural rehabilitation. Maybe most importantly, there is a lack of understanding of the experiences of individuals with hearing loss, and what it takes to succeed. This problem drives my research with a certain urgency.

Beyond hearing loss
Admittedly, there is more beyond just my hearing loss that I need to address. I have a natural tendency toward qualitative methods. In my early explorations, I quickly realized that this type of research was very much in line with who I was, how I thought about the world and how I learned. After high school, I chose to go to Assumption College, a small, Catholic, liberal arts university. There I went through the honors program. I had to take a series of courses designed to teach higher order critical thinking skills focused on the understanding of philosophies and theologies, igniting the call to service, and unleashing a young, idealistic but passionate crowd onto the world’s problems. We read Mountains beyond Mountains, Tracy Kidder’s story of Paul Farmer, a doctor who worked in Haiti’s hospitals, and learned about the passion he pours into his work. In my community service learning class, we read Another Bullshit Night in Suck City, analyzing the both the narrative and the literary devices of the novel, which chronicled the life of a homeless father and his social worker son. Armed with this new information, we conducted an interview project with homeless men and women of Worcester, and in the academy of the real world, we relearned everything we thought we knew.

I kept these books instead of selling them back. Years after graduation, I read a Readers Digest article about a doctor in Ethiopia doing similar work to Farmer. I tore it out and tucked it inside my journal. I studied the stories that these authors portrayed, how the authors captured informants’ voices, what the messages meant. It seemed urgent that I keep these stories- I mostly wanted to capture the way the stories ignited a fire within. I wanted to do good work and help the world see truths in the same way. I didn’t yet know how I would do this. Now, it seems significant that I was introduced to interview methodologies so early in my academic career. I think it allowed for an early appreciation for methodologies beyond the more mainstream research traditions in audiology.
How this study came about

I forged ahead with grad school, though there were certainly days that threatened to extinguish my drive. In part, some classes seemed hollow echoes of reality. I had entire semester-long courses on how to test hearing or how to program devices. I was frustrated, because to me, a hearing test or programming the device is just 45 minutes in a year of a person with hearing impairment. I was learning how to test hearing, and fit devices, but we didn't spend enough time discussing how complicated the identity of being a person with hearing loss was, how individuals with hearing loss have a higher rate of comorbid physical and mental health issues, how hearing loss can make education or employment more difficult. These are things that really matter to in the daily lives of individuals with hearing loss. There were classes that did focus on this aspect of hearing loss, but I found the readings thin, and the lessons learned did not capture the essence of the hearing loss experience.

There were some bright spots though. I learned of patient-centered care through an independent study with Dr. Kris English, and an extra-curricular class on chronic illness. I began to wonder why this principle was not already in practice, after all, isn’t the patient be the expert on their own life? Around the same time, I started an independent study with my advisor, Dr. Kathleen Cienkowski, and in doing so, I digested the listening effort literature. Each Sunday night I’d read the articles, highlight critical points, and annotate positive or negative attributes or questions in the margins. Sitting in her office on Thursdays before lab meetings, we’d dissect each article. I learned about quality scientific rigor, good writing styles, different types of data analysis. As we worked through this scholarship, I pushed back too, asking why real world tests weren’t considered in these studies. After all, life is not lived in a perfectly controlled sound treated booth with the noise source in back of the participant and the signal of interest in front.
Having just moved to an apartment full of new sounds, I was constantly on high alert, and connected this to the listening effort experience. Dr. C countered with how culture might also influence an individual’s perception of listening effort. While we appreciated the current literature, I grew increasingly convinced that the literature inadequately captured the listening effort experience.

Slowly, like the way fog dissipates off of UCONN’s Mirror Lake, it became clear that I am approaching this project in this way because I am deaf, but equally so, because I am me. My dissatisfaction with the current literature undeniably arises from my still unanswered questions about my own identity, from my frustrations with the fact that I am seen as a "model deaf student,” which is meant as a compliment but strikes me as an easy way to dismiss the work the field needs to do to empower individuals with hearing loss. Additionally from my own attraction to ways of knowing more common in the liberal arts than the sciences.

What happened during the study

Throughout the research project, I followed the advice of every qualitative research guide, and regularly memoed about the research participants, results, and process. Part of this was due to contractual obligation: I had included in the plan for the dissertation regular documentation of field notes on nuances and impressions from the interviews directly after the interviews. This journaling will be utilized to help support the interpretation of the interview meanings. This process can also address and document the interviewer’s subjectivities so that the research process can avoid including as much unconscious subjectivity as possible.
These early notes were type-written and sterile, void of any real meat, but I completed them. It was more often that I’d come to a profound thought or realization driving in my car, standing in line at the grocery store, walking across campus. When this happened, I repeated the idea to hold it in my brain until I could get to a place where I could write it down. These notes were scribbled onto sticky notes and taped into my research journal, recording the subjective moment, inherent connections that I noticed, a theme that suddenly emerged. Later, as I had threads and themes to hold onto, memoing became less of a chore, and more of a frenzied effort to document the explosion of thoughts and ideas that was happening. I was able to record lively memos full of realizations and special moments that had happened in the interview that lent insight. These memos were the beginnings of analytic moments about my subjectivity that helped to shape this chapter.

My participants’ reactions to finding out about my hearing loss was an enjoyable and surprising aspect of my project. I followed the model that I had carefully developed in my clinical work. In the clinic, I don’t parade my hearing loss about during the appointment, but I don’t actively hide it either. When a moment arises where it might be appropriate to disclose my hearing loss, I have always followed the Hippocratic oath- “First, do no harm”. I tried to imagine whether this patient would be harmed by what I have to say. Are they in a position where they may potentially be hurt by my introduction of my hearing loss? If not, then the second step always follows, are they in a position where they may potentially be helped by my introduction of my own hearing loss? If the answer to the first question is no, and the answer to the second question is yes, then I proceed with introducing my hearing loss in a genuine as possible way. Most times, my patients outright notice my devices and ask me about them. This is how I tried to
approach my hearing loss while interviewing patients, though the standard oath isn’t always as straightforward in an interview setting.

Participants who knew me personally and already knew that I had a hearing loss sometimes explained their story and followed it up with, “Well you probably know what that’s like”. I tried to follow this up with comments such as, “Well, tell me more about what it’s like for you?” Sometimes I would chuckle and say “It’s your life, not mine, tell me about how you think it’s affected you!” When I recognized instances where there may have been a bias in real time, I tried to give clarifying statements about what “you” feel.

Other participants did not know I had hearing loss prior to the interview, and we never discussed it. I tried not to introduce it too early into the interview because I didn’t want to influence an interviewee’s natural storytelling process, and I tried to introduce it only when it was pertinent. I rarely did not disclose my hearing loss, as it felt like I was hiding something. I wanted to be as honest and transparent as possible with subjects who were willing to be honest and transparent with me about such a personal topic.

Some individuals were referred to me by friends of theirs who had been previous participants. I had no idea what that referring friend had or had not said about my hearing loss when they discussed the study, though I treated the interviews like they didn’t know. Two participants directly asked me about my hearing status in the beginning of the interview. One started to tell me her story, hesitated for a split second, and then made a comment about how since we were in a safe space, she wanted to ask if I had a hearing loss myself. I responded that I did, and then she continued her story. The other participant and I were chatting before the interview started across from each other at a round table. I was setting up my iPad to record the video and leaned to the left. She must have caught glimpse of my cochlear implant, and said
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“Oh, I see you have hearing aids too!” I smiled, replied. “Yes, I do have a hearing loss and I wear cochlear implants.” “Wow that’s great!,” she replied, and then we moved on like we had just discussed the weather.

And there were other participants to whom I disclosed my hearing loss before, during, or towards the end of the interview for some specific reason. For example, one participant asked if - after the interview -- she could ask me questions about assistive devices and tools she could use to improve her experience with hearing loss. At that point I disclosed that besides my clinical doctoral training, I had a hearing loss myself, so I had personal and professional experience with hearing loss. And between the two, I could probably find an answer to her questions. She replied to my email back in three minutes “!!!! OMG, you get it!!!! Look forward [to our meeting]”. When I did disclose, participants either gasped with disbelief or smiled a warm and knowing smile.

Revealing my hearing loss framed my interactions with participants. I often explained how I was dissatisfied with the (relative) lack of attention that this topic was getting because I knew it to be such an important component of my own hearing loss, and I was doing this research, hoping to better define the factors that are involved with listening effort. I’m not sure how this was interpreted by participants, but I got the sense that they were grateful for my work and that they felt like I was “one of them.”

Participants often commented in ways that made me feel like the work was valuable. “I would be happy to volunteer, as I’ve worn hearing aids 33 years and I’ve complained about the fatigue factor for years!” was the kind of comment I would receive when potential participants asked for additional information about the study. “Auditory fatigue is a topic that I think is incredibly relevant! I’m in!” another person wrote in an email. My doctoral student colleagues
had difficulty recruiting subjects for their respective studies, and I was surprised to find I didn’t have to search very hard for participants at all. I sent out three emails to community contacts to distribute to their databases. Subjects responded so quickly that I was scheduling three or four weeks out. Participants repeatedly told me how thankful they were that I was there to ask these questions because no one had ever asked them about this before. “We are your cheerleaders, you go girl!”

Their enthusiasm fuels my drive. Several asked if I would publish this research. They wanted to know in what journals it would be printed, so they could read it. They also wanted to know if it would be published in Barnes and Noble Booksellers or American Association of Retired Persons (AARP) magazine, so that a wider audience would read it.

It appears that my participants felt like I was one of them, I knew what hearing loss and listening effort was like. They insisted that I share this information with those audiologists who don’t understand what listening effort is like. Some gave me hugs after the interview, even though we had just met that very day. I was often surprised by these touching gestures, and so I tried to treat the moment with the specialness it deserved. I thanked them for being so open with me and for sharing their story for the sake of research. Afterwards, as I walked away smiling from these moments, I hoped that their embrace was because they trusted me with their story, that we were fighting this battle of hearing loss together.

These feelings are complicated. Perhaps my informants entrusted me with information that they may not otherwise share with researchers who do not have hearing loss. I have heard gripes about hearing instrument specialists, audiologists, aural rehabilitationists, professionals, family members and even their own spouses. I try not to say anything, though I do sometimes smile, because I too have gripes with my audiologists, aural rehabilitationists, family members,
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and my partner. We smile at each other with the shared understanding that we complain here in the context of the interview, but we also truly appreciate these people in our lives. Yes, our spouses may shout at us from the living room, but they do lots of other things that help us too.

It’s hard to know if a researcher without hearing loss would be able to elicit the same responses. Surely, on a superficial level, a researcher without hearing loss would be able to relate to their own partners who annoy them about the laundry not making the hamper or the lights being left on. But there’s a deeper undercurrent there that I’m not sure a researcher without hearing loss would easily understand. For example, one participant disclosed how she found that the camp dining hall where she and her extended family summer was exhorbitantly difficult to listen in. She mentioned that she bought three Roger pens. A relatively high end, new piece of technology, Roger Pens are fairly costly investments for our patients, running upwards of at least $600, which means that this subject spent at minimum, $1800 on 3 of these devices. To anyone else, this may seem like an extreme and wasteful amount of money. However, while I haven’t bought three Roger pens, I know what it’s like to find a piece of technology that works, and the relief it brings. I can easily understand her willingness to purchase the device, though I’m not sure that others without hearing loss would be as readily accepting of this. My subjects and I face challenges that words cannot fully capture, and my informants repeatedly said that the hearing people in their lives “don’t get it and don’t understand”.

Sometimes our shared experiences might have caused me to presume I understood something that was said, when I should have probed for more insight. For example, two participants mentioned the term “passing” in their daily lives, and it was only later that I realized that I had taken the term for face value, because I knew what they meant instantaneously. However, I realized that we might have different understandings of “passing”. I documented the subjective
A moment in my journal, and resolved to probe the next time someone used that term. Soon enough, a third participant mentioned passing, and I was able to catch it and ask her what she meant by it. Obviously, without definitions from the previous participants, I can’t tell if her personal meaning of passing, was the same as the others, but it certainly matched mine.

While my hearing loss can be advantageous for understanding, it can also be terribly disabling in ways beyond my dead hair cells. It is always the case with interpretive work that my informants might have told me things they thought I wanted to hear. Hearing loss is an isolating condition. It is well known how the disability causes a lack of audibility, which impairs communication, and subsequently affects social interactions, which have can have a profound impact on the individual. It is reasonable within the context of this exploration, where an interested party with hearing loss herself is asking about a topic of listening effort, my participants might scavenge their life for any shred of evidence to support my inquiries in order to form a connection with someone like them. And because of my own experiences, I may have turned a blind eye- or more apropos- a deaf ear and accepted these stories as truth without further examination. It takes constant vigilance to check and recheck that the patterns I report are consistent across participants, across methods, and across members of the research team.

A story unfolding

This study is one step in a longer saga, a story both of the field of audiology and my own unfolding identity as a researcher with hearing loss who studies hearing loss. I am deeply aware of the complexity of my position, of how my own subjectivities provide me access to others’ perspectives that might be unique. And also act as blinders in ways that I may not fully understand.
In interviews, I learned both about hearing loss and about myself. One participant discussed how she often overcompensated for hearing loss. In listening to her tell of how she overprepared for her teaching responsibilities -- writing careful lesson plans, prepping lectures with handouts and multimedia, figuring out how she was going to handle student questions she might not be able to hear -- I heard echoes of my own life. My parents and academic advisors have often asked me if I’m taking on too much. I typically dismissed these comments as well intentioned but largely irrelevant. But in this interview, I paused, seriously considering if -- and when -- I was trying to overcompensate for my hearing loss.

While I tried to manage my subjectivities throughout the study through reflection and journaling, it was during coding that I checked and rechecked my interpretations more systematically. For every finding, I sought to engage in critical re-analysis to ensure that my own history wasn’t over-interpreting results that weren’t there. This occurred especially with the social relationship code. I had my own history of childhood bullies and marginalizing comments. To verify that I wasn’t being pulled under by my own subjectivities, I called in my advisor to read through examples with me. She pointed out that what I was calling “social pain” was probably more like a miscommunication. This was essential in the process, and I continued to keep my head above the murky subjective deeps with the help of my research team.

Looking back, this research is indubitably shaped by my own experiences with hearing loss, but frankly, it’s even more shaped by me as a researcher. Then again, so are other pieces of qualitative, and even quantitative research. Investigators typically generate questions on topics that they’re interested in for a myriad of their own reasons. Like Peshkin (1988) argues, through this critical analysis, I’ve gained a sense of how my own history and the findings of this project meet. Hopefully this becomes apparent to the reader as well.
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