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A comparison of voice amplifiers and personal communication systems in individuals with hypophonia: An exploration of communicative participation

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Abstract

Hypophonia is one of the most prevalent speech impairments in hypokinetic dysarthria. Unfortunately, behavioral interventions for hypophonia often fail to generalize beyond the clinic. An alternative approach to management is the use of speech amplification devices. This study evaluated how 17 individuals with hypophonia (HP) and their primary communication partners (PCPs) rated communicative participation across three, one-week device trial periods at home. Amplification devices included: a wired belt pack amplifier, wireless stationary amplifier, and personal FM system. Patient-reported outcome measures included the CES, VAPP and PIADS. Results indicated HPs rated participation higher following device use in comparison no device. Further, HP and PCPs rated these measures similarly suggesting PCPs can be used reliably as proxies. Finally, the FM system produced the overall highest VAPP ratings and second highest CES ratings. This study will serve to inform evidence-based prescription of speech amplification devices from a multi-dimensional approach for individuals with hypophonia.

Keywords: Parkinson's disease, hypophonia, speech amplification devices, communicative participation

Summary for Lay Audience

Hypophonia, or reduced speech loudness, is one of the primary speech features of Parkinson's disease. Estimates suggest that hypophonia is present in approximately 42-49% of individuals with hypokinetic dysarthria. Hypophonia can hinder verbal communication in social contexts and can be a disabling aspect of Parkinson's disease, affecting communicative participation. Communicative participation is defined as taking part in life situations where knowledge, information, ideas, or feelings are exchanged. It may take the form of speaking, listening, reading, writing or nonverbal means of communication. Speech treatment for hypophonia typically aims to increase speech loudness. Unfortunately, behavioral speech interventions for hypophonia often fail to generalize beyond the clinic. An alternative approach to management is the use of speech amplification devices. The present study is part of a larger study that explored the performance of three speech amplification devices across the parameters of speech-to-noise ratio and speech intelligibility. What remains unexplored is an evaluation of these amplification devices from the perspective of communicative participation. This study evaluated how individuals with hypophonia and their primary communication partners rated communicative participation: 1) before and after experience with an amplification device, and 2) across three different amplification devices following trial periods outside of the laboratory. Amplification devices included a wired belt pack amplifier, a wireless stationary amplifier, and a two-way personal communication system. Seventeen participants with hypophonia and their primary communication partners participated in a study in which they tested the three speech amplification devices in a laboratory environment as well as during one-week trial periods at home. Outcome measures included the Communicative Effectiveness Survey (CES) and the Voice Activity and Participation Profile (VAPP). Results indicated participants with hypophonia rated participation higher following device use in comparison to no device. Further, both groups rated these measures similarly across device conditions suggesting primary communication partners can be used reliably as proxies, if required. Finally, the two-way personal communication system emerged as the amplification device producing the overall highest VAPP ratings and second highest CES ratings. The current study complements previous acoustic and perceptual efficacy data that will inform evidence-based prescription of amplification devices from a multi-dimensional approach.

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1 Introduction

1.1 Parkinson's disease

Parkinson's disease (PD) is a slowly progressive degenerative neurological disease of the central nervous system (Duffy, 2013; Hirsch et al., 2016; Jankovic, 2008). Parkinson's disease, originally termed "shaking palsy" by James Parkinson in 1817 described a medical condition characterized by "an involuntary tremulous motion, with lessened muscle power, in parts not in action and even when supported" (Parkinson, 1817, p.1).

James Parkinson's medical description of "shaking palsy" was later refined in the 19th century and was expanded upon by Jean-Martin Charcot in the mid-1800s (Charcot, 1872 as cited in Goetz, 2011; see also Jankovic, 2008; Kalia & Lang, 2015). Charcot re-named "shaking palsy" to *Parkinson's disease* in honour of James Parkinson. The clinical feature of bradykinesia was added as a separate cardinal feature of PD, and tremor-dominant and rigid/akinetic forms were distinguished as separate phenotype of PD (Duffy, 2013; Goetz, 2011; Jankovic, 2008; Kalia & Lang, 2015). Since the original description, the clinical diagnosis of Parkinson's disease has centered on a defined motor syndrome. Specifically, the cardinal motor symptoms of PD include resting tremor, rigidity, bradykinesia, postural instability, and gait impairment (Duffy, 2013; Gibb & Lees, 1988; Jankovic, 2008; Kalia & Lang, 2015).

In 2015, a task force from the International Parkinson and Movement Disorder Society (MDS) published "Clinical Diagnostic Criteria for Parkinson's disease" (MDS-PD-CDC). The goal of these criteria was to standardize clinical diagnosis, both for research and for clinical practice. When defining the criteria, the task force members noted that there was not a reliable objective test for diagnosing Parkinson's disease available. Therefore, expert opinion remains the gold standard for diagnosing Parkinson's disease (Postuma et al., 2018). Explicitly, Parkinsonism is defined as bradykinesia, in combination with either rigidity and resting tremor, or both (Postuma et al., 2018). The characteristic of postural instability in individuals with PD can present as another feature

of parkinsonism, however, it is not part of the MDS-PD criteria due to the fact that it often occurs in later stages of Parkinson's disease (Postuma et al., 2015). A clinical diagnosis of PD is made when at least two cardinal motor symptoms are present (Verstreken, 2016). Non-motor manifestations can also occur in individuals with Parkinson disease. These non-motor manifestations can include sleep disturbances, cognitive dysfunction, gastrointestinal dysfunction, and sensory abnormalities (Dashtipour et al., 2018; Duffy, 2013; Jankovic, 2008; Kalia & Lang, 2015; Postuma et al., 2015; Verstreken, 2016). As such, these non-motor features are now incorporated into the diagnostic criteria of PD (Postuma et al., 2015). Additionally, individuals with PD can also develop axial motor symptoms such as freezing of gait, dysphagia and dysarthria (Duffy 2013; Jankovic, 2008; Mekyska et al., 2018). Although dysarthria often does not emerge for several years after the first signs of PD, it becomes evident in approximately 70-90% of individuals with Parkinson's disease (IWPD) over the course of the disease (Duffy, 2013).

1.2 Epidemiology

Parkinson's disease affects approximately 8 million individuals worldwide (Sapir, 2014). As such, Parkinson's disease is the second most common neurodegenerative disease following Alzheimer's disease (De Lau & Breteler, 2006; Verstreken, 2016; Wirdefeldt, Adami, Cole, Trichopoulos & Mandel, 2011). Over 100,000 Canadians currently live with PD, and more than 25 Canadians each day are diagnosed with Parkinson's disease (Parkinson Canada, 2020; see also UCB Canada, n.d.; PHAC, 2014). PD affects 1 in every 500 Canadians and approximately 6,600 new cases of PD are diagnosed each year, based on an annual incidence of 20 new cases per 1000,000 people (Hirsch et al., 2016; UCB Canada, n.d.). The cause of idiopathic Parkinson's disease remains unknown, but risk factors for developing PD are multifactorial and include a combination of genetic and environmental factors. These risk factors include increasing age, sex differences, ethnicity, previous family history of PD or tremor, exposure to pesticides, herbicides, metals, and solvents, consuming well-water, and prior head injury (Duffy, 2013; Kalia & Lang, 2015). The prevalence of PD increases with age and affects 1-2% of the population above 60 years of age (Duffy, 2013). This number increases with age, peaking at

approximately 80 years old (Ashcerio & Schwarzchild, 2016; Tysnes & Storstein, 2017). Epidemiological studies have demonstrated sex differences as a risk factor for developing PD. Males are more likely than females to develop PD at a ratio of 3.7 to 1.37 (Baldereschi et al., 2000; Van Den Eeden et al., 2003), with a large meta-analysis study suggesting that, in any specific time-frame, twice as many men than women suffer from Parkinson's disease (Elbaz et al., 2002).With an aging population and increasing life expectancy worldwide, it is estimated that the number of people with Parkinson's disease may increase by more than 50% by 2030 (Kalia & Lang, 2015; NINDS, 2020; PHAC, 2014).

1.3 Pathophysiology

Parkinson's disease is associated with basal ganglia pathology. The basal ganglia is a group of subcortical nuclei located deep in the cerebral hemispheres (Duffy, 2013). These subcortical nuclei include the striatum, global pallidus (internal and external), sub-thalamic nucleus and substantia nigra pars compacta (Sapir, 2014). The basal ganglia construct the control circuit of transmitting neurons which are responsible for and contribute to motor control, initiation, and termination of voluntary movements. The basal ganglia also contribute to the maintenance of posture and static muscle contraction (Duffy, 2013). More specifically, the basal ganglia control circuit serves to regulate muscle tone, control postural adjustments, and scale the force, amplitude, and duration of movements. The basal ganglia also serve to adjust movements to the environment, and assist in the learning, preparation and initiation of movements (Duffy, 2013). In Parkinson's disease, damage to the basal ganglia control circuit either reduces movement or results in a failure to inhibit and execute involuntary movement (Duffy, 2013; R.D. Kent, J.F. Kent, Weismer, & Duffy, 2000). Imbalances among neurotransmitters are responsible for many motor problems associated with basal ganglia control circuit malfunction. The actions of dopamine transmitters are of particular importance to understanding Parkinson's disease (Duffy, 2013). With the loss or destruction of dopamine secreting neurons within the substantia nigra, the dopamine supply to the striatum is reduced and its role in the circuit is diminished (Duffy, 2013).

Additionally, lesions occurring in the basal ganglia result in the neurochemical loss of dopaminergic pathways, which in turn, results in cell death (Adams & Jog, 2009). When dopamine stores reach approximately 80% depletion, the emergence of Parkinson's disease symptoms appear which is correlated to disease severity (Wirdefeldt et al., 2011). For individuals with PD, the loss of dopamine results in an overactivation and a chemical imbalance in the thalamus to accurately send messages to the motor cortex, which corresponds to the presentation of the cardinal symptoms of PD (Adams & Jog, 2009; Fox & Ramig, 1997; Kalia & Lang, 2015; Ramig, 1998) and axial motor symptoms, such as freezing of gait and hypokinetic dysarthria.

1.4 Hypokinetic Dysarthria

Dysarthria is defined as "a collective name for a group of neurologic speech disorders that reflect abnormalities in the strength, speed, range, steadiness, tone or accuracy of movements" (Duffy, 2013, p.4). The abnormalities are critical for respiratory, phonatory, resonatory, articulatory or prosodic aspects of speech production (Duffy, 2013). The most predominant framework for the differential diagnosis of dysarthria comes from the foundational work of Darley, Aronson and Brown (1969a). Darley et al., (1969a) identified seven distinct types of dysarthria: flaccid, spastic, ataxic, hypokinetic, hyperkinetic, unilateral upper motor neuron and mixed presentations. Their method of classification relies heavily on the auditory-perceptual attributes of speech that relate to the locus of the underlying neuro-pathophysiology.

Of particular interest, hypokinetic dysarthria is a perceptually distinct motor speech disorder, affecting aspects of speech motor control, such as the preparation, maintenance and switching of motor programs (Duffy, 2013). Hypokinetic dysarthria is most often associated with Parkinson's disease, and it accounts for approximately 10% of all dysarthrias (Duffy, 2013). The term "hypokinetic" reflects the effects of rigidity, reduced force and range of movement, as well as, slow, but sometimes fast repetitive movements during speech production (Duffy, 2013).

Approximately 70-90% of individuals with Parkinson's disease will develop communication problems including speech and voice impairments related to hypokinetic

dysarthria (Adams & Dykstra, 2009; Andreetta et al., 2016; De Keyser et al., 2016; Logemann, et al., 1978; Miller et al., 2006; Sapir, Ramig, Hoyt, et al., 2002; Sapir, Ramig & Fox, 2008; Trail et al., 2005). In their 1969 landmark study, Darley and colleagues described the most deviant features of hypokinetic dysarthria (listed in order from most to least severe) as monopitch, reduced stress, monoloudness, imprecise consonant articulation, inappropriate silences, short rushes of speech, harsh vocal quality, breathy vocal quality, low pitch, variable rate, increased rate in segments, increased overall rate, repeated phonemes. Of these speech dimensions, monopitch, reduced stress, monoloudness, inappropriate silences, variable rate, increased rate in segments, increased overall rate, and repeated phonemes were described as distinctive to hypokinetic dysarthria when compared to other dysarthria types (Darley et al., 1969a). Reduced loudness or hypophonia is also considered a distinguishing and abnormal speech feature commonly observed in hypokinetic dysarthria (Darley, Aronson & Brown, 1975; Dromey & Adams, 2000; Duffy, 2013).

1.5 Hypophonia

Hypophonia is one of the primary speech features of Parkinson's disease and it often emerges as an initial speech symptom in the beginning stages of the disease (Adams & Dykstra, 2009; Logemann et al., 1978). Despite the prevalence of hypophonia as a speech symptom of hypokinetic dysarthria, the pathophysiological mechanisms underlying hypophonia in PD are complex and poorly understood. It has been suggested that a sensorimotor integration deficit may play a role in the perception of speech loudness in hypophonia (Andreetta et al., 2016; Clark et al., 2014; Ho, Bradshaw & Iansek, 2000). Ho et al., (2000) proposed that hypophonia in PD is related to abnormalities in sensorimotor integration involving the abnormal integration of the sensation of one's own loudness during speech motor output. Sensory-perceptual deficits can also manifest as difficulties in sensory self-perception of effort or in the scaling of motor output and effort (Lewis & Byblow, 2002). For example, when individuals with Parkinson's Disease are asked to produce loud speech or to increase their motor output, they can increase their otherwise quiet speech to a normal intensity level. However, these individuals report as if they feel they are talking "too loud" (Sapir, 2014). In addition to scaling abnormalities,

individuals with PD are often able to increase their speech intensity when explicitly cued by a listener, though they are not able to spontaneously maintain or make adjustments to their speech intensity (De Keyser et al., 2016; Ho, Bradshaw, Iansek & Alfredson, 1999a).

Estimates suggest that hypophonia is present in approximately 42-49% of individuals with hypokinetic dysarthria (Gamboa et al. 1997; Ludlow & Bassich, 1984). This perceptual finding has been studied empirically across a number of studies that have documented reduced speech intensity in PD (Adams et al., 2006a; Fox & Ramig, 1997; Ho et al., 1999a). In general, these studies have indicated that participants with PD have speech intensity levels that are, on average, 2-5 dB SPL (decibels; sound pressure level) lower than healthy age-matched control participants (Adams et al., 2006b; Fox & Ramig, 1997). A robust literature demonstrates that individuals with PD present with hypophonia and can have difficulty regulating speech intensity in conversational tasks (Adams et al., 2006b; Fox & Ramig, 1997; Ho et al., 1999a; Ho, Iansek, & Bradshaw, 1999b; Ho, et al., 2000; Kempler & Van Lancker, 2002; Moon, 2005; Tjaden, 2006). This finding is in contrast with a number of previous studies that have not found significant differences between individuals with PD and control participants using other speech tasks such as reading (Canter, 1963; Kempler & Van Lancker, 2002; Metter & Hanson, 1986) and sentence imitation tasks (Ludlow & Bassich, 1984; Tjaden, 2006). It has been proposed that hypophonia in PD may be exacerbated in more linguistically and attentionally demanding tasks, such as conversational speech (Dykstra, Adams & Jog, 2012b). Further, acoustically challenging speaking environments, such as background noise further exacerbates hypophonia in individuals with PD as compared to healthy control participants (Adams et al., 2008; Adams et al., 2006a; Dykstra, Adams & Jog, 2012a; Ho et al.,1999a). It is prudent, therefore, to obtain a valid estimate of hypophonia in naturalistic, but also acoustically challenging speaking environments such as in background noise, and more demanding speech tasks, such as conversational speech, where hypophonia will be most evident (Adams et al., 2006a; Dykstra et al., 2012a; Fox & Ramig, 1997) and will have an effect on speech intelligibility (Dykstra, Adams & Jog, 2012b).

1.6 Relationship between Speech Intensity and Speech Intelligibility

Speech intelligibility has been defined as the "behavioural standard of communication" and as the "degree to which the speaker's intended message is recovered by the listener" (Kent 1992; Kent et al., 1989). More broadly, speech intelligibility can be viewed as the "understandability of speech" (Kent, 1992; Yorkston, Dowden & Beukelman, 1992). Speech intelligibility supports effective and efficient spoken language (Dykstra et al. 2012b). Within the discipline of speech-language pathology, a primary intervention goal for most individuals with communication disorders is to maximize speech intelligibility through the use of effective treatment modalities (Duffy, 2013) in order to improve functional communication (Harkins & Tucker, 2007; Sussman & Tjaden, 2012). Many individuals with PD and hypokinetic dysarthria present with reduced speech intelligibility (Adams et al., 2006b) due to a combination of articulatory and prosodic deficits. However, for individuals with hypophonia as their primary dysarthric feature, maintaining adequate speech intelligibility can also present as a difficult and a challenging task (Dykstra et al., 2012b; see also Adams et al., 2008). This is due to the detrimental effect that reduced speech intensity regulation can have on speech intelligibility (Dykstra et al., 2012b). For individuals with PD and hypophonia, speech intelligibility can be relatively unimpaired during tasks that involve estimated speech intelligibility based on single word or sentence intelligibility tasks but can be degraded in conversation (Dykstra et al., 2012b; Tjaden, 2006).

These task-based differences are likely due to the greater attentional and linguistic demands of conversational speaking tasks, versus less demanding tasks such as producing single words, sentence reading, or imitation (Dykstra et al., 2012a). Despite these documented task-based differences, speech intelligibility is typically evaluated using highly controlled stimuli such as sentence reading, single-word or sentence-level tasks (Dykstra et al., 2012b). Therefore, it is possible that the actual speech intelligibility of speakers with hypophonia is underestimated when less demanding speech tasks are utilized during assessment (Dykstra et al., 2012b). Numerous studies have demonstrated task-based differences in intelligibility scores (e.g., Kempler & Van Lancker, 2002;

Rosen, Kent & Duffy, 2005; Weismer, 1984, as cited in Bunton & Keintz, 2008; Tjaden & Wilding, 2011; Dykstra et al., 2012a). For example, Kempler and Van Lancker (2002) demonstrated task-based speech intelligibility differences in an individual with Parkinson's disease. The results of their study found that the speech intelligibility score demonstrated a significant difference between poor (29%) intelligibility of spontaneous conversational speech compared with better (78-88%) intelligibility in reading, repeating and repeated singing tasks (Kempler & Van Lancker, 2002). These findings lead to spontaneous speech conditions results in less efficient speech because the dysfunctional basal ganglia is lacking an adequate generated planning model. In contrast, the reading and repetition conditions may benefit from the presence of the aid in planning, initiating and monitoring of the speech gestures (Kempler & Van Lancker, 2002), suggesting that the type of speech tasks can have a significant effect on intelligibility scores obtained from individuals with Parkinson's disease.

1.7 Treatment of Parkinson's disease

The reduced ability to communicate is considered to be a difficult aspect of the disease as reported by individuals with Parkinson's disease and their families (Trail et al., 2005). Treatment for hypokinetic dysarthria typically aims to increase speech intensity, improve prosodic aspects of speech production, reduce rate of speech, and/or increase articulatory precision (Adams & Dykstra, 2009). Common treatment approaches for Parkinson's disease and for the speech and voice impairments resulting from hypokinetic dysarthria consist of pharmacotherapy, neurosurgery, behavioural speech therapy, biofeedback and assistive devices, or a combination thereof (Adams & Dykstra, 2009; Andreetta et al., 2016; Dashtipour et al., 2018; Ramig, 1998; Rousseaux, 2003; Trail et al., 2005). Although pharmacotherapy is the most common approach for treating the classic motor symptoms of Parkinson's disease, it is not necessarily prescribed for the explicit treatment of impaired speech and voice production. Evidence supports the use of levodopa and dopamine agonists at all stages of the disease for treating motor symptoms (Connolly & Lang, 2014). Despite the effectiveness of these medications for treating motor symptoms, levodopa and dopamine agonists have been shown to produce limited

or inconsistent results in the improvement of speech and voice performance associated with Parkinson's disease (Adams & Dykstra, 2009; Dashtipour et al., 2018).

Although not specifically recommended as a treatment for hypokinetic dysarthria, a more recent medical intervention for treating motor symptoms of Parkinson's disease, is neurosurgery. Deep brain stimulation of the subthalamic nucleus (STN-DBS) is an effective medical intervention for more advanced Parkinson's disease. STN-DBS has been demonstrated across numerous studies to result in a significant reduction of dopaminergic medication use, drug-induced dyskinesias, and long-term improvement of all cardinal motor symptoms of PD (Groiss et al., 2009). It may be possible to adjust stimulation settings to optimize speech such as using a lower frequency and lower voltage which may improve speech intelligibility, voice quality and speech intensity (Knowles, Adams, Abeyesekera, Mancinelli, Gilmore & Jog, 2018). However, similar to pharmacotherapy, STN-DBS has also demonstrated inconsistent results with respect to speech and voice impairments associated with PD, with some patients reporting adverse speech outcomes (Skodda, 2012). Taken together, these findings suggest that pharmacological and neurosurgical approaches alone do not improve speech and voice performance consistently and significantly. As such, biofeedback and behaviourally based speech therapy approaches should be considered for improving speech and voice symptoms even for optimally medicated individuals with Parkinson's disease and for those who have undergone neurosurgical procedures (Trail et al., 2005).

Behavioural and biofeedback therapy approaches for individuals with hypokinetic dysarthria and Parkinson's disease target improvement of various aspects of speech and voice impairments. One of the most commonly prescribed behavioural interventions for treating reduced speech intensity for individuals with hypokinetic dysarthria is called *Lee Silverman Voice Treatment* (LSVT), developed in 1988 by Dr. Lorraine Ramig and colleagues (Ramig, Schere, Titze, et al., 1988). The premise of LSVT is to increase speech intensity by increasing phonatory effort and laryngeal adduction and to recalibrate the sense of effort required to achieve appropriate levels of speech intensity (Ramig, Fox & Sapir, 2004). LSVT is an intensive, high effort speech treatment compromised of both non-speech and speech drills designed to rescale the amplitude of motor output of

speakers with hypokinetic dysarthria and to maximize phonatory and respiratory functions (Ramig, 1998; Ramig, Countryman, O'Brien, Hoehn & Thompson, 1996; Ramig et al., 2001, see also Pinto et al., 2014). Clinical efficacy of LSVT has been demonstrated through increased vocal loudness and sustained improvement in vocal perception in individuals with PD following treatment (Ramig et al., 2001; Ramig et al., 1994; Sapir et al., 2002). Specifically, in Ramig et al. (2001), LSVT resulted in significant improvement in vocal loudness and voice fundamental frequency for three different speech tasks (Rainbow Passage, sustained "ah", monologue) immediately post-treatment and from pre-treatment to 24 months follow-up. The results of this study concluded individuals with Parkinson's disease who were treated with LSVT were likely to maintain related improvement in vocal function up to two years after treatment (Ramig et al., 2001).

On the contrary, there are concerns that the primary focus of LSVT on laryngeal activation and intensity may be regarded as too narrow to be applicable to most individuals with hypokinetic dysarthria because reduced speech intensity is just one of several abnormal speech parameters that should be addressed in treatment (Adams & Dykstra, 2009). In addition, reduced speech intensity may be related to laryngeal and additional non-laryngeal processes, such as respiratory function**,** reduced oral opening, posture, rate of speech, and dysfluencies. Clinical efficacy data has primarily been obtained from measures in the clinical setting. There is limited evidence; however, demonstrating the efficacy of LSVT in ecologically valid environments outside of a clinical speech treatment environment (Adams & Dykstra, 2009; Körner Gustafsson et al., 2013; Schalling et al., 2013; Wight & Miller, 2015).

In an attempt to address the issue of the ecological validity of LSVT, Bryans and colleagues (2020) studied the impact of LSVT LOUD on functional communication and participation for individuals with Parkinson's disease. Their findings suggested that LSVT LOUD promoted an increased sense of personal control over the communication difficulties resulting from PD (Bryans et al., 2020). Bryans and colleagues (2020) concluded that for individuals with PD, LSVT LOUD may reduce the risk of social isolation by improving communication and facilitating social participation. A number of

studies have evaluated and examined maintenance of treatment gains, however more evidence is needed regarding maintenance of treatment changes outside of the clinical environment (Bryans et al., 2020; Miller et al., 2011; Spurgeon et al., 2015). For these reasons, it is recommended that clinicians identify the impact of PD on functional communication at baseline, the specific concerns and goals of each individual, and the barriers to treatment (Bryans et al., 2020; Schelling et al., 2013). It has also been noted that individuals with Parkinson's disease have raised concerns about their ability to maintain and generalize their gains outside of the clinic setting, this may be due to a number of physical and psychosocial issues that may be unaddressed in traditional therapy (Bryans et al., 2020).

Several reports have examined the effectiveness of biofeedback visual devices for the treatment of speech disorders in PD (Hand, Burns & Ireland, 1979; Johnson & Pring, 1990; Netsell & Cleeland, 1973; Rubow & Swift, 1985; Scott & Caird, 1981, 1983; Yorkston, Beukelman & Bell, 1988). Biofeedback is "a process of transducing a physiologic variable, transforming the signal to extract useful information, and displaying that information to the subject in a format that will facilitate learning to regulate the physiological variable" (Rubow, 1984, p.207 as cited in Yorkston, Spencer & Duffy, 2003). Outcomes of biofeedback treatment for physiologic impairment are usually measured in physiologic terms. For example, the level of subglottal air pressure generated during certain speech production tasks, excursion of the abdominal and rib cage during speech, or sound pressure level during sustained phonation (Yorkston, Spencer & Duffy, 2003). Many of the speech dimensions that are most impaired in PD, such as pitch variation, speech loudness, and speech rate, can be easily displayed using a variety of laboratory instruments (Adams & Dykstra, 2009). These instruments can include pitch meters, sound level meters, and oscilloscopes (Adams & Dykstra, 2009). For example, Visipitch, manufactured by Kay Elemetrics in 1989, is a computer-based program that provides real time visual displays of pitch and loudness, which is becoming a standard treatment modality in the clinical setting (Adams & Dykstra, 2009). Duffy (2013) concluded that biofeedback can be effective in changing physiologically measured variables related to respiratory/phonatory problems associated with dysarthria. It has been demonstrated that the addition of biofeedback and behavioural treatment approaches for

hypokinetic dysarthria provides greater treatment gains than those achieved with using neurosurgery and pharmacotherapy alone (Adams & Dykstra, 2009).

In 2013, Schelling and colleagues studied biofeedback in the form of a vibration signal using the device, VoxLog, to track daily voice use over three weeks in a case study of six individuals with Parkinson's disease and hypophonia (Schelling et al., 2013). The results of this study demonstrated a statistically significant increase in voice sound level when the feedback was administered. These results suggest that biofeedback administered in this manner may be a useful clinical tool for this group of patients (Schelling et al; 2013). The majority of the research to date has focused on administering biofeedback while practicing specific tasks in clinical situations. However, the information about the effect of feedback delivered during daily activities is limited (Schelling et al., 2013).

An issue with biofeedback and behavioural speech therapy approaches for the treatment of hypokinetic dysarthria is the maintenance and transfer of gains made following these various treatments (Adams & Dykstra, 2009); known as the "transfer of treatment" issue (Rubow & Swift, 1985; see also; Gaballah et al., 2019, Adams & Dykstra, 2009). Rubow and Swift (1985) demonstrated that an individual with Parkinson's disease showed negligible improvements of their speech treatment beyond the clinic. Many individuals with PD face additional challenges such as memory impairment and slowness of cognitive processing (Costa et al., 2008; Nordenberg & Sundberg, 2004; Pfeiffer et al., 2014; Poletti et al., 2012). These factors may contribute to difficulties with maintenance of new skills or behavioural changes learned in treatment and can play a role in the reports of poor treatment effects in this population (Oxtoby, 1982 as cited in Schelling et al., 2013). As such, biofeedback and behavioural speech therapies have been criticized because improvements made within the clinical setting during treatment fail to transfer into natural speaking environments (Adams & Dykstra, 2009; Andreetta et al., 2016). The "transfer or treatment issue" is arguably one of the most important concerns in the treatment of hypokinetic dysarthria in Parkinson's disease.

1.7.1 Speech Amplification Devices

A potential solution to the "transfer of treatment" issue is the use of assistive speech amplification devices. Assistive speech amplification devices are a type of portable augmentative and alternative communication device that serves to amplify an individual's natural voice (Andreetta et al., 2016). In Parkinson's disease, speech amplification devices can be used in the management of hypophonia (Andretta et al., 2016; Knowles et al., 2020). According to the American Speech-Language-Hearing Association (1989), these devices "attempt to compensate (either temporarily or permanently) for the impairment and disability patterns of individuals with severe expressive communication disorders" (p.107). Early preliminary reports by Greene, Watson, Gay and Townsend (1972) suggested that speech amplification devices may contribute to significant improvements to speech intelligibility and speech intensity by increasing the audibility of speech and by facilitating self-correction through self-monitoring. An advantage of assistive speech devices is that they require little instruction or training, and users are not required to develop new patterns of behaviour (Adams & Dykstra, 2009). Further, the use of speech amplification devices can provide immediate benefit to an individual's communication and this benefit will remain in effect for as long as the individual continues to utilize the assistive device (Adams & Dykstra, 2009).

Speech amplification devices can be divided broadly into two categories: voice amplifiers and personal FM systems (Adams & Dykstra, 2009). Voice amplifiers can be further divided into two main classes of devices: portable and stationary. Portable, wired voice amplifiers typically have a speaker system that is worn on the body, for example, belted around the waist, clipped to a pocket, or worn on a lanyard. Attached to this portable amplifier is a headset or lavalier microphone which is worn by the user (Knowles et al., 2020). Stationary voice amplifiers include a microphone that is attached to a small unit, either body-worn, on a chair or bed, that transmits the speech signal wirelessly to an audio speaker located up to several meters away from the talker (i.e., similar to a portable public address system) (Knowles et al., 2020; see also Duffy, 2013). A personal FM system is the other main category of speech amplification devices. Similar to voice amplifiers, a personal FM system may represent a potentially effective type of

amplification system that has rarely been considered in the treatment of individuals with Parkinson's disease (Andreetta, 2013). Personal FM systems have been previously used by individuals with hearing impairments (Harkins & Tucker, 2007; Laplante-Lévesque et al., 2010), but have not yet been previously reported for use for individuals with hypophonia and PD with the exception of recent study by Knowles et al. (2020). Personal FM systems are typically wireless and transmit the audio signal over a frequency modulation (FM) or a very-high frequency (VHF) channel. These systems typically include a small, body-worn transmitter. Unlike voice amplifier devices, personal FM systems are designed to transmit the signal to a small receiver designed to be worn with headphones, typically worn by the person with hearing loss (Knowles et al., 2020). More specifically, an FM system is a lightweight, headset microphone worn by the individual with Parkinson's disease, which transmits their speech wirelessly to a pocket-sized VHF receiver and amplified through headphones worn by their communication partner.

Using an FM system as a treatment for hypophonia is considered a novel approach because this type of technology has primarily been studied and used for the hearing impairment population. Regardless of the style of speech amplification device, the main purpose of these devices is to increase the intensity of the speech signal. An advantage to this type of management is that speech intelligibility and speech intensity can be improved without the need for any behavioural adjustments (Knowles et al., 2020). The use of speech amplification devices has been demonstrated to decrease vocal effort for individuals with Parkinson's disease and hypokinetic dysarthria, and result in more successful communication, with fewer requests for message repetition by listeners (Andreetta et al., 2016). Yorkston, Spencer, and Duffy (2003) further reported the beneficial effects of assistive speech amplification devices such as improvements in the perceptual aspects of speech production, such as loudness and intelligibility which can be effective for speakers with reduced loudness who have not experienced success with other forms of interventions.

1.8 Communicative Participation

Communicative participation is increasingly being recognized as an important outcome domain in rehabilitation research because the information that is provided by an

individual with a health condition gives a unique insider perspective (Eadie et al., 2006). Communicative participation is defined "as taking part in life situations where knowledge, information, ideas, or feelings are exchanged. It may take the form of speaking, listening, reading, writing or nonverbal means of communication" (Eadie et al., 2006, p.309). Communicative participation can occur in multiple life situations or domains that include, but is not limited to, personal care, household management, leisure, learning, employment and community life (WHO, 2001 as cited in Eadie et al., 2006). Communicative participation has been examined in Parkinson's disease across several studies (Baylor et al., 2011; Donovan et al., 2008; Dykstra, Adams & Jog, 2015; Garcia, Laroche & Barrette, 2002; McAuliffe, Baylor & Yorkston, 2017; Miller et al., 2006) demonstrating interferences to communicative participation as a result of the disease.

Baylor et al. (2011) examined interferences to communicative participation in 44 adult participants representing seven different medical conditions, including Parkinson's disease. Participants with PD identified variables in which they had little or no control over that impacted communicative participation. The first variable identified as creating interferences to communicative participation were the speech symptoms resulting from their diagnosis of PD. Participants reported feeling restricted in the ability to project their voice with adequate loudness in order to be heard and reported difficulty producing "clear" and "distinct" speech. Mobility was another variable that produced an interference to communicative participation for participants with PD. Reduced mobility resulted in restrictions to communicative participation because of the difficulties keeping up with and maintaining social commitments (Baylor et al., 2011). Finally, environmental factors were identified as barriers to successful communicative participation. Background noise such as traffic or machinery, as well as people talking or singing, were identified as barriers to participation because these noise sources created distractions resulting in language processing and language formulation difficulties (Baylor et al., 2011). Further, most individuals reported that group conversations were especially challenging and created participation restrictions because they felt "left out" of the conversation and cited difficulties participating in conversational turns, keeping up with the rapid pace of a conversation, and attempting to start a new conversational topic (Baylor et al., 2011). Finally, using the telephone was reported as a barrier to successful communicative

participation because of reduced speech intelligibility and the loss of nuanced communication through body language or facial expressions that was important for conveying communicative intent. Overall, all participants in the Baylor et al., (2011) study reported significant restrictions to communicative participation across a variety of contexts and environments.

Garcia, Laroche and Barrette (2002) studied work integration issues in individuals with a variety of communication disorders, including those with Parkinson's disease. The results of this study revealed common barriers to an individual's employment, similar to Baylor et al. (2011), which included background noise, telephone use, group situations, the need for rapid communication, and the attitudes and awareness of the communication partners in the workplace. The ability to be gainfully employed and satisfied with one's occupation was also reported as a valued role in life participation (Garcia et al., 2002).

Miller and colleagues (2006) sought to establish if, and how, changes in communication impact individuals with PD, and explored how these individuals develop coping strategies to deal with the changes to communication. The results of this study found communication changes directly impacted socialization. This ranged from being anxious to interact to social withdrawal. These changes were generally experienced in terms of the effect on an individual's overall communication, and in their roles and relationships (Miller et al., 2006). Miller and colleagues identified a list of positive coping strategies used by their study participants that included: the balance of energy required for communication versus energy required for other needs; compensation for physical aspects of voice-speech deterioration; and the engagement of listeners for building successful exchanges. These coping strategies were included because Miller and colleagues found that the actual speech and voice changes were not the main concern, but rather it was the impact that these strategies had on self-concept and communicative participation inside and outside friend and family dynamics. Along with effective support from communication partners, it was concluded that individuals with PD must be aware of their own strengths and limitations because communication changes had a significant impact on daily living for individuals with PD and their families (Miller et al., 2006).

Communicative effectiveness, a component of communicative participation has been explored across several studies (Donovan et al., 2007; Donovan et al., 2008; Dykstra et al., 2015). Communicative effectiveness is defined as a person's ability to successfully communicate messages in home and community settings to fulfill life roles (Hustad, 1999). Donovan and colleagues (2008) used the Communicative Effectiveness Survey (CES; Donovan et al., 2007) to examine self-rated communicative effectiveness in individuals with hypokinetic dysarthria secondary to Parkinson's disease. Twenty-five participants with PD and dysarthria, and 25 control participants used the CES to self-rate communicative effectiveness. Additionally, 25 primary communication partners of IWPD used the CES to rate the communicative effectiveness of their partner with PD. The results of this study concluded that individuals with PD reported reduced communicative effectiveness as compared to control participants (Donovan et al., 2008). Furthermore, the mean self-reported CES rating of the PD group was significantly higher than the mean CES rating made by primary communication partners suggesting that proxy's rate IWPD significantly more impaired than IWPD rate themselves. Hypotheses suggested by the authors to explain this finding were that IWPD may lack insight due frontal lobe executive dysfunction (Donovan et al., 2008, see also Fleming et al., 2005; Bodis-Wollner, 2003; Ferreri, Aghokou & Gauthier, 2006; Lauterbach, 2005) or may be due to a sensorimotor deficit that can result in a mismatch between actual performance and judgement of performance (Abbruzzese & Berardelli, 2003; Ho et al., 1998).

Dykstra et al., (2015) studied the relationship between speech intensity and self-rated communicative effectiveness using the CES in 30 participants with PD presenting with hypophonia as their primary dysarthric feature, and a control group of 15 healthy older adults. The findings of this study revealed that individuals with PD self-reported significant reductions in communicative effectiveness relative to control participants. The CES items "Having a conversation with others at a distance" and "Having a conversation while travelling in a car" accounted for approximately 61.5% and 57% of the variance between participants with PD and control participants, respectively. Furthermore, individuals with PD and hypophonia self-reported difficulty communicating and participating effectively across a variety of speaking situations such as having a long conversation, speaking before a group, speaking in a noisy environment, or having a

conversation with a stranger over the telephone (Dykstra et al., 2015). As a result, these diverse speaking environments and contexts provide further evidence that acoustically challenging contexts such as background noise and increased interlocuter distances result in ratings of reduced communicative effectiveness in individuals with hypophonia and PD (Dykstra et al., 2015).

Communicative participation has been studied formally utilizing a patient-reported outcome measure called the Communicative Participation Item Bank (CPIB; Baylor, Yorkston, Eadie, Miller & Amtmann, 2009). Several research studies have used the CPIB as a primary outcome measure in studies across a variety of communication disorders (see; Baylor et al., 2011; Baylor et al., 2014; McAuliffe, Baylor & Yorkston, 2017) and have found interferences to communicative participation across a number of clinical populations, including PD.

One of the first studies to use the CPIB was conducted by Baylor and colleagues (2010), the creators of the CPIB (see Baylor et al., 2009). This study explored variables associated with self-reported communicative participation using the CPIB in a sample of community-dwelling adults with multiple-sclerosis (MS) (Baylor et al., 2010). The results of this study found that reduced communicative participation was not solely based on the communication disorder, but included variables such as fatigue, depression, and social support (Baylor et al., 2010).

To examine communicative participation in individuals diagnosed with Parkinson's disease, McAuliffe and colleagues (2017) used the CPIB to identify variables associated with communicative participation in PD and examined the relationship between the CPIB and existing health-related quality-of-life measures. The findings of this study revealed that communicative participation was influenced by a complex set of variables. While perceived level of speech impairment was self-reported as the greatest contributor to communicative participation, the perceived presence of cognitive symptoms was also significantly associated with communicative participation outcomes (McAuliffe et al., 2017). Furthermore, higher levels of speech usage were also associated with improved perception of communicative participation. That is, participants who communicated a

greater amount, reported higher levels of communicative participation (McAuliffe et al., 2017). While self-reported speech difficulty and cognitive symptoms were associated with interference to communicative participation, other variables including country of residence, age, fatigue, emotional issues, and the presence of co-occurring swallowing problems were also reported (McAuliffe et al., 2017). For example, increased fatigue and swallowing difficulties had significant negative associations with communicative participation. The presence of cognitive symptoms and emotional issues were associated significantly with lower levels of communicative participation (McAuliffe et al., 2017).

The Voice Activity Participation Profile (VAPP; Ma & Yiu, 2001) was designed to assess the impact of an individual's self-perception of voice problems, activity limitations, and participation restrictions in individuals with voice disorders (Ma & Yiu, 2001). While originally validated on individuals with dysphonia, it has since been administered to individuals with Parkinson's disease (IWPD) that presented with speech and voice difficulties (Simberg et al., 2012). Simberg and colleagues (2012) sought to evaluate the impact of a 15-day intensive speech treatment protocol on the speech and voice of six IWPD. Prior to beginning the treatment protocol, IWPD completed the VAPP so a baseline measure of activity limitations and participation restrictions could be obtained. Six months and one year following the treatment onset, individual self-ratings of voice-related activity limitations and participation restrictions were evaluated using the VAPP. The researchers found that participants' self-ratings of their overall VAPP scores showed a significant decrease from pre-treatment to six months post-treatment, suggesting an improvement in participation (i.e., decreased restrictions to participation). Furthermore, VAPP scores remained stable one-year post-treatment. Communication partners (i.e., spouses) of IWPD also evaluated their partner's voice-related activity limitations and participation restrictions using the VAPP and reported an improvement in participation post-treatment. It was concluded that patient-reported outcome measures and proxy ratings provide valuable insight to the perspectives of individuals with communication disorders (Simberg et al., 2012).

The results of the studies described above (Baylor et al., 2013; Donovan et al., 2008; Dykstra et al., 2015; McAuliffe et al., 2017; Miller et al., 2006; Simberg et al., 2012)

highlight the importance of considering the multi-faceted nature of communicative participation in assessment and treatment planning for individuals with Parkinson's disease and hypokinetic dysarthria. Taken together, these studies demonstrate that these individuals (including those with hypophonia) report interferences to communicative participation and this body of research provides a rationale for the continued study and inclusion of this construct. Several scholars who study the disablement process in neurogenic communication disorders have advocated for the inclusion of participation-based patient reported outcome measures. For example, it has been suggested that communicative participation reflects the final common pathway for many aspects of disablement and functioning (Yorkston, Klasner & Swanson, 2001), it may be considered a universal outcome that is common to both individuals with and without communication disorders (Eadie et al., 2006). Finally, it has been suggested that communicative participation inclusion advances our understanding of the impact of interventions and provides a multidimensional lens of rehabilitation (Threats, 2006).

The empirical study of communicative participation as a distinct construct is critical for understanding how individuals with communication disorders meet the communication needs of their daily lives, how various interventions mediate or moderate communicative participation, and how it can elucidate any interferences experienced in their communicative participation. Being a distinct construct, communicative participation must be measured directly and not inferred from the degree of physical impairment or performance of basic skills (Baylor et al., 2009). Therefore, the degree of impairment (e.g., severity of hypophonia) should not be equated with a similar degree of interference to communicative participation. This finding was demonstrated in Dykstra and colleagues (2015) study showing that speech intensity and communicative effectiveness were not significantly correlated. Their finding suggests that communicative participation cannot necessarily be predicted from the severity of hypophonia in participants with PD.

For clinicians and researchers alike, the acknowledgement of communicative participation as a separate and distinct construct from impairment-based outcomes has bolstered its use as an important and critical intervention target and outcome indicator for individuals with communication disorders. In addition to more traditional outcomes, such

as speech intelligibility or speech intensity measures, the inclusion of patient-reported outcome measures targeting communicative participation can help ensure that speech language pathology (SLP) interventions are making relevant and meaningful differences in the lives of their clients (Baylor et al., 2013). Despite the advances made in our understanding of interferences to communicative participation for individuals with PD and hypophonia, what remains understudied and poorly understood is how communicative participation is rated and experienced following interventions targeted at increasing speech intensity and/or improving speech intelligibility.

In addition to studying and measuring communicative participation in this clinical population, it is also of interest to study and measure the psychosocial impact of assistive device use on participation for individuals with hypophonia using assistive devices, such as voice amplifiers. The Psychosocial Impact of Assistive Devices Scale (PIADS; Day & Jutai, 1996) has been utilized to assess the effects of assistive devices on functional independence, well-being, and quality of life. The PIADS was developed to fill the need for a reliable, valid, and economical measure that is generically applicable across all major categories of assistive technology (Day & Jutai, 1996). Preliminary investigations (Arberas, Fernández & Menéndez, 2019; Barrett & Taylor, 2010; Bevilacqua et al., 2020; Jamwal et al., 2017; Tofani et al., 2020) suggest that the PIADS has excellent potential for testing and building theories about the psychosocial factors associated with the use of assistive technology.

For example, Jamwal and colleagues (2017) aimed to identify electronic assistive technology types used by individuals with acquired brain injuries. In this study, user satisfaction and the psychosocial impact of electronic assistive technology types were analyzed. In addition to the impact of technology use on respondents' participation and support needs, the barriers and/or facilitators to uptake and continued use of electronic assistive technology were identified. Using the PIADS, this study indicated that electronic assistive technology use positively impacted psychosocial outcomes related to life role participation, including the ability to participate (join in activities with other people), the ability to take advantage of opportunities (act quickly and confidently when

there is a chance to improve something), adequacy (capable at handling life situations and minor crises), and competence (ability to do well in the important things you need to do).

The PIADS has also been studied in Parkinson's disease. Bevilacqua and colleagues (2020) have recently initiated a study protocol aimed at evaluating an innovative rehabilitation treatment, using robotic devices, for adults with PD. A variety of outcome measures, including the PIADS, will be administered to participants in order to evaluate an innovative rehabilitation treatment designed to improve the gait and to reduce the risk of falling. Participants with PD will be given a variety of questionnaires that take into consideration different aspects of their health status such as, the Mini-mental state examination (MMSE; Folstein, Folstein, & McHugh, 1975), Hoehn and Yahr scale (HYS; Hoehn & Yahr, 1967), Barthel index (BI; Mahoney & Barthel, 1965) and the PIADS, to name a few. Specifically, the PIADS will be used to measure the "acceptance of technology" at the end of the treatment protocol to determine the efficacy of two robotic devices (Tymo system and TecnoBody) on self-ratings related to availability of new experiences, improvement of skills, and self-esteem (Bevilacqua et al., 2020).

1.9 Rationale for Current Study

Andreetta et al. (2016) and Knowles et al. (2020) have evaluated a variety of speech amplification devices prescribed to individuals with PD and hypophonia by examining and evaluating performance-based, objective speech measures such as speech intelligibility and SNR, as well as subjective speaker preference ratings such as device preference. What remains unexplored is an evaluation of devices based on patient-reported outcome measures related to communicative participation. It is anticipated that data obtained from communicative participation outcome measures will complement the performance-based, objective speech measures obtained by Knowles et al., (2020) by broadening our understanding of the factors necessary for successful device acceptance in this clinical population. Further, it is anticipated that the analysis of communicative participation outcome measures across various amplification devices, in conjunction with previous efficacy data, (acoustic and perceptual) will ultimately serve to inform evidence-based prescription of speech amplification devices for individuals with hypophonia.

1.10 Purpose

The current study is part of a larger primary study that examined and evaluated user preference and performance of three amplification devices (i.e., Chattervox, Nady, WA120BT, Nady 351VR) across acoustic (SNR), and perceptual (speech intelligibility) dimensions in quiet and in background noise conditions (Knowles et al., 2020). The purpose of the current study extends the research of Knowles et al. (2020) by evaluating how individuals with hypophonia and their primary communication partners rate communicative participation: 1) before and after experience with a speech amplification device, and 2) across three different amplification devices following trial periods outside of the laboratory. The ultimate goal of this research is to provide specific recommendations for the use of amplification devices for this population from the perspective of patient-reported communicative participation.

Five main objectives were examined in this study. These objectives sought to:

1. Evaluate if ratings of communicative participation differ across pre- versus post-device use.
2. Evaluate if there are differences in self-rated communicative participation across the three devices.
3. Determine if ratings of communicative participation differ for individuals with hypophonia versus their primary communication partners across device conditions.
4. Determine if a device hierarchy exists based on patient reported outcome measures related to communicative participation, and if this potential device hierarchy maps onto the device hierarchy proposed by Knowles et al. (2020) based on variables related to device preference, and performance-based objective speech measures of SNR and speech intelligibility.
5. Determine if final device selection is associated with patient-reported outcome data in the three device trial periods. (For example, is there a difference between dyads that selected a device and those that did not select a device in the questionnaire data obtained during the pre-device trial period).

Chapter 2

2 Method

2.1 Participants

Data for the current study were obtained from a larger data set collected by Knowles et al. (2020) that sought to identify device preference and the performance of three amplification devices hypothesized to improve speech intensity and speech intelligibility for individuals with hypophonia and PD. Human Subjects Research Ethics Board Western University approved this study (HSREB:106169), and it was registered as a clinical trial (ClinicalTrials.gov Identifier: NCT02407067) (see Appendices A and B). Two groups participated in this study: a group of individuals with hypophonia (HP) and their primary communication partners (PCP).

2.1.1 Participants with Hypophonia

The participants included 17 individuals with hypophonia (4 females, 13 males, age range 54-78 years; referred to as the HP group for this study) recruited from the Movement Disorders Clinic at University Hospital in London, Ontario, Canada. Of these individuals, 15 had primary diagnosis of idiopathic PD confirmed by their primary neurologist, (MJ). One individual had a primary diagnosis of Multiple Systems Atrophy-predominant cerebellar ataxia (MSA-C), and one had a diagnosis of possible parkinsonism. All individuals were judged to have hypophonia by an experienced movement disorder neurologist (MJ). Inclusion criteria for the HP participants included that they, a) had received a neurological diagnosis at least six months prior to testing; b) exhibited mild to moderate hypophonia (as rated by an experienced speech-language pathologist, (SA)); c) were between the ages of 50 and 85 years; d) had no history of other neurological or voice disorders and, e) were otherwise in good general health. All HP participants were stabilized on antiparkinsonian medication, with the exception of one participant (HP13), who had recently adjusted his medication schedule. Seven participants had received deep brain stimulation surgery (DBS) of the subthalamic nucleus as an adjunctive intervention to treat the symptoms of PD. Eight participants had previously received speech therapy to address speech concerns related to PD. Hearing and cognitive status were screened but

were not exclusion criteria. Hearing screenings were done at a 40-decibel hearing level (dB HL) threshold at 500Hz, 1kHz, 2kHz, and 4kHz in both ears, and failing the screening was not an exclusion criterion. Eight HP participants passed the hearing screening and ten participants failed at one or more frequencies. Cognitive status was not an exclusion criterion, though the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) was used to screen for cognitive impairment. Participant demographics for the hypophonia group is presented in Table 1.

2.1.2 Primary communication partners

The second group of participants were individuals serving as "primary communication partners" (PCP) to their respective partner (i.e., HP participants). The primary communication partner group included 17 individuals (13 females, 4 males, age range 54-79 years). Prior to primary study enrollment conducted by Knowles et al. (2020), each potential HP participant was instructed to select someone in their daily life with whom they spoke regularly to accompany them to all study visits. In the 17 cases, this was a spouse and in one case it was an adult child (PCP13). In order to not place restrictions on the selection of the communication partner most appropriate for the HP participants, the only inclusion criteria for the PCP group included that they were between 18 and 85 years of age. Hearing status was not an exclusion criterion but hearing screenings for the PCP group were completed. Screenings were done at a 40 dB HL threshold at 500Hz, 1kHz, 2kHz, and 4kHz in both ears, and failing the screening was not an exclusion criterion. Four PCP participants did not pass the 40 dB HL hearing screening (PCP04, PCP07, PCP17, PCP21) and did not wear hearing aids. Two PCP participants did have hearing aids (PCP06, PCP14). The role of the PCP participants was to provide device ratings alongside their partner throughout the trial periods, including outcome measures related to communicative participation.

Table 1

Demographic information of participants with hypophonia (HP group) and primary communication partners (PCP group)

Participant	Sex	Age	Diagnosis	Years Since Diagnosis	DBS	UPDRS	UPDRS-Speech	MoCA	HP Hearing Screening	PCP Hearing Screening	Level of Speech Usage	CPIB Total Summary Score
HP01	M	75	PD	9	No	40	3	16	Fail	Pass	I	16
HP02	M	54	PD	7	Yes	31	3	22	Fail	Pass	U	3
HP03	M	75	PD	8	No	29	2	23	Fail	Pass	U	12
HP04	F	78	PD	14	No	35	2	20	Fail	Fail	I	6
HP06	M	67	PD	21	Yes	29	3	22	Fail	Hearing Aids	U	9
HP07	F	72	PD	16	No	30	1	26	Pass	Fail	R	22
HP08	M	65	PD	15	No	20	1	21	Pass	Pass	U	22
HP11	M	72	PD	11	Yes	NA	NA	20	Pass	Pass	I	10
HP12	M	59	PD	10	Yes	37	2	24	Pass	Pass	I	12
HP13	M	71	PD	0.5	No	31	1	22	Fail	Pass	I	28
HP14	F	67	PD	31	Yes	43	2	19	Fail	Hearing Aids	I	4
HP16	M	70	PD	17	Yes	18	2	23	Fail	Pass	I	14
HP17	M	71	MSA-C	5	No	23	2	27	Fail	Fail	I	10
HP18	M	72	PD	2	No	45	3	25	Fail	Pass	U	0
HP19	M	59	MSA-P	8	No	52	3	26	Pass	Pass	I	22
HP21	M	60	PD	12	No	17	2	29	Pass	Fail	I	22
HP22	F	68	PD	15	Yes	36	1	25	Pass	Pass	I	15

Note. HP = Hypophonia. PD = Parkinson's disease; MSA-C = Multiple Systems Atrophy Cerebellar Type; MSA-P = Multiple Systems Atrophy Parkinsonian Type; DBS =Deep brain stimulation; UPDRS = Unified Parkinson's Disease Rating Scale; Speech = Speech item score from the UPDRS; MoCA = Montreal Cognitive Assessment; PCP = Communication partner; I = Intermittent speech usage; R = Routine speech usage; U = Undemanding speech usage

2.2 Materials

2.2.1 Devices

Based on the recommendations of Andreetta et al. (2016) and the Knowles et al. (2020) protocol, four device conditions were included: a pre-device condition and three device conditions referred to as Devices A, B, and C. It was anticipated that these three devices would capture an array of device styles, device capabilities, and appeal differently to each participant dyad based on factors such as lifestyle, communication needs, and speech symptoms (Knowles et al., 2020).

Device A. Device A is a portable wired belt pack speech amplifier (Chattervox; 5 Watts) whereby the talker wears a lightweight, headset microphone connected to an external speaker worn as a belt pack (Knowles et al., 2020).

Device B. Device B (Nady WA120BT; 20 Watts) is similar to the BoomVox (see Andreetta et al. (2016) for description) in form and function, consisting of a lightweight, wireless headset microphone (Nady HM20) that transmits wirelessly over a Very High Frequency channel (VHF) to a larger, stationary speaker that projects the speech from up to several meters away from the talker. The external speaker is 21cm x 26cm x 13cm, weighs 2.4 kg, and has multiple possible audio adjustments, including volume, echo, treble, and bass (Knowles et al., 2020).

Device C. Device C (Nady351VR) is similar to the Phonic Ear Easy Listener body-worn FM systems previously tested for use with individuals with hearing loss (Crandell, Charlton, Kinder, & Kreisman, 2001). A lightweight, headset, microphone (Nady HM20) worn by the talker transmits the speech wirelessly to a pocket-sized VHF receiver, which is then amplified through headphones worn by the listener. Devices similar to Device C have been used with individuals with hearing loss (e.g., EasyListener). In the primary study by Knowles and colleagues (2020), the IWPD participants wore the microphone, and the PCP participants wore the headset.

2.2.2 Patient-reported outcome measures

The HP participants were instructed to complete the patient-reported outcome measures from their own perspective, whereas the PCP participants were instructed to complete the same set of patient-reported outcome measures in the context of its use by his/her partner.

Levels of Speech Usage. The Levels of Speech Usage (LSU; Baylor et al., 2008) is a self-report scale that can be used to efficiently describe and code speech usage for clinical and research purposes (Baylor et al., 2008). Speech usage refers to how individuals utilize their speech to meet communication demands in life roles (see Appendix C). It is described in terms of the amount, frequency, type, and importance of speaking situations that people might encounter in daily activities (Baylor et al., 2008). While completing this questionnaire, participants are instructed to select the everyday degree of speech usage from five different categories: undemanding, intermittent, routine, extensive, and extraordinary (Baylor et al., 2008). Clinicians may find the scale to be a helpful starting point for a conversation with an individual about his/her speech needs and priorities, and how these might be addressed in intervention (Baylor et al., 2008).

Communicative Participation Item Bank. The Communicative Participation Item Bank (CPIB; Baylor et al., 2009) is a patient-reported outcome measure that targets the construct of communicative participation (Baylor et al., 2013). The CPIB is a dynamic, self-report outcome measurement tool appropriate for clinical trials, research, and clinical practice (Baylor et al., 2013). It is designed for administration to community-dwelling adults across a variety of communication disorders, included motor speech, voice, and mild-to-moderate cognitive-communication disorders (Baylor et al., 2009). Baylor et al. (2013) validated the CPIB across four clinical populations that commonly present with communication disorders: multiple sclerosis, Parkinson's disease, amyotrophic lateral sclerosis, and head and neck cancer (HNCA; oral, oral-pharyngeal, or laryngeal cancer). These clinical populations were chosen because they are adult-onset conditions whereby individuals have experienced living as "typical" communicators before the onset of their condition. To have this perspective provides a baseline from which individuals can evaluate how their health condition has impacted communicative participation.

The short form of the CPIB consists of 10 items that reflect life situations that adults regularly participate in (see Appendix D). All items in the CPIB start with the stem "Does your condition interfere with…" followed by various conversational situations. These items range from easy to difficult situations. For example, an easier item may be talking to a family member in the home, whereas a more difficult item may include speaking in noise or to a stranger or over the telephone. An example item is: Does your condition interfere with talking to people you know? Respondents choose from four response categories to rate the level of interference they experience in that situation. Then, each item is rated on a 3-point scale ranging from "not at all" (3) to "very much" (0). The CPIB is scored by summing the 10 items. The scores for the items are added together to obtain a summary score. The summary score can range from 0 to 30, with higher scores being more favorable, and lower scores indicating greater difficulty in participation. The summary scores can be converted to item response theory (IRT) theta values (logit scale). On the logit scale, scores typically range from -3.0 to +3.0, with 0 logits representing the mean for the calibration sample. The scoring guide associated with the CPIB also includes a conversion to standard T scores (M=50, SD=10). In IRT, the person's score is based on the parameters of the individual items administered to that person (Baylor et al., 2013).

Communicative Effectiveness Survey. The Communicative Effectiveness Survey (CES; Donovan et al., 2007; Appendix E) was created from both the Communication Effectiveness Index (CETI) developed by Lomas and colleagues (1989) and the modification of the CETI proposed by Hustad (1999) for use by individuals with dysarthria. The original CETI was developed to measure the functional communication of adults with Aphasia (Lomas et al., 1989). It was intended to be completed by a proxy, such as the primary communicative partner of an individual with Aphasia, using a 100 mm visual analogue scale (VAS) consisting of 16 functional situations rated from "not at all able" to "as able as before the stroke" (Lomas et al., 1989). In 1999, Hustad modified the original Communicative Effectiveness Index (CETI-M; Lomas et al., 1989) in order to develop an assessment of communicative effectiveness for individuals with motor speech disorders (Hustad, 1999). Hustad proposed a modified 10-item CETI, rated on a 7-point Likert scale with the anchors "not at all effective" (1) to "very effective" (7) in

order to elicit ratings of communicative effectiveness in everyday situations for individuals with dysarthria (Hustad, 1999).

In 2007, Donovan and colleagues revised the items and scoring procedures of the CETI-M and renamed it the Communicative Effectiveness Survey (CES). The CES is an 8-item patient-reported outcome measure of communicative effectiveness across different communicative contexts and situations. Using a 4-point Likert scale ranging from "not at all effective" (1) to "very effective" (4), individuals rate how effectively they communicate in each of the eight communicative contexts and situations. The means of the sums for each individual question are used to designate the ratings of communication effectiveness in that context. In 2008, Donovan and colleagues validated the CES for use with individuals with Parkinson's disease and found that the CES demonstrated strong item-level psychometric properties (similar to classical test theory terms of face validity, content validity, and consistency of response). Based on those results, the CES was judged to be a viable measure of communicative effectiveness for individuals with PD and dysarthria (Donovan et al., 2008, see also Donovan et al., 2005, Donovan et al., 2007). The CES provides clinicians and researchers a short, efficient assessment of common situations consistent with participation, such as talking with family members at home, in a car, over the telephone, at a distance, as well as, expressing feelings and opinions (Donovan et al., 2007; Dykstra et al., 2015).

Voice Activity and Participation Profile. The Voice Activity and Participation Profile (VAPP; Ma & Yiu, 2001; Appendix F) is a 28-item patient reported outcome measure that evaluates the activity limitations and participation restrictions of individuals with voice disorders, such as dysphonia (Ma & Yiu, 2001); laryngeal impairments (Bermúdez-de-Alvear et al., 2019); vocal complaints (Ricarte, Oliveira & Behlau, 2013); and other various functional and organic voice disorders (Sukanen et al., 2007). The VAPP is divided into five sections: self-perceived severity of voice problem, effect on job, effect on daily communication, effect on social communication, and effect on emotion. Each item is scored on a 100 mm visual analog scale (VAS) with the anchors "never" and "always." The distance measured from the left end of the scale to where the respondent placed a mark on the line is used to score each item (Ma & Yiu, 2001). Each section of

the questionnaire constitutes a Section Score, with differing maximum scores. The sum of the five Section Scores gives rise to the Total Score, a maximum of 280. Items in each of Sections 2, 3, or 4, can be further computed to give rise to two additional scores for each section. The Activity Limitation Score (ALS) is computed from the first question of each category which ascertains the extent of activity limitation. These questions include the following: "*Is your job affected by your speech problem?", "Do people ask you to repeat what you have just said because of your speech problem?", "Does your speech problem affect you in social activities?".* The Participation Restriction Score (PRS) is computed from the second question of each category which ascertains the extent of participation restriction. These questions include the following: *"In the last six months, have you thought of changing your job because of your speech problem?", "In the last six months, have you ever avoided talking to people because of your speech problem?", "In the last six months, have you ever avoided social activities because of your speech problem?".* The ALS from Sections 2,3, and 4 are summed to give the Total ALS. In addition, the PRS from Sections 2,3, and 4 are summed to give the Total PRS (Ma & Yiu, 2001). The relationship between the ALS and PRS for each individual can provide a result of significance for each subscale section.

Information provided by the VAPP enables clinicians to address the voice needs of individual clients in these separate subscale sections (Ma & Yiu, 2001). This information can reveal to clinicians an indication of discrepancies between the individual's perception of his/her voice problems which can be compared with measures of the severity of the voice impairment (Ma & Yiu, 2001). Ma and Yiu (2001) highlighted that the severity of dysphonia obtained using acoustic and perceptual measures does not necessarily reflect the impact of voice disorders on an individual.

Psychosocial Impact of Assistive Devices Scale. The Psychosocial Impact of Assistive Devices Scale (PIADS; Day & Jutai, 1996; Appendix G) is a 26-item patient-reported outcome measure designed to assess the effects of an assistive device on functional independence, well-being, and quality of life. The PIADS was developed to fill the need for a reliable, valid, and economical measure that is generically applicable across all major categories of assistive technology (Day & Jutai, 1996). Research on the

PIADS has established that the instrument has good internal consistency, test-retest reliability and construct validity (Day, Jutai & Campbell, 2002). It is a responsive measure and sensitive to important variables such as the user's clinical condition, device stigma, and functional features of the device. It has been shown to accurately reflect the self-described experiences of people who use assistive devices. The PIADS has excellent potential for testing and building theories about the psychosocial factors associated with the use of assistive technology. There are three subscales of the PIADS: Competence, Adaptability, and Self-esteem. The Competence subscale (12 items) includes questions on topics such as competence, productivity, usefulness, performance, and independence. The second subscale, Adaptability (6 items), indicates a willingness to try out new things and to take risks. The third subscale, Self-esteem (8 items), indicates feelings of emotional health and happiness (Day & Jutai, 1996). The scoring system is based on a 7-point Likert scale, measuring the way that assistive devices affect different areas of everyday life user's experience from a positive to a negative perspective. For reference, -3 is maximum negative impact, zero is no impact and +3 is maximum positive impact where the in-between would be either somewhat negative or somewhat positive. High positive scores indicate positive impacts on quality of life (Day & Jutai, 1996). The PIADS has good validity for predicting device use and discontinuance, which can be used reliably by caregivers to give proxy ratings of device impact and produces valid results. The PIADS has excellent potential for testing and building theories about the psychosocial factors associated with the use of assistive technology (Jutai & Day, 2001).

2.3 Procedure

2.3.1 Protocol

The current secondary study employed a clinical crossover design to compare ratings of communicative participation across three types of amplification devices used by individuals with hypophonia and PD: 1) a wired belt pack voice amplifier (Device A), 2) a wireless personal amplifier (Device B), and 3) a wireless personal communication system (Device C). The primary investigator (TK) explained the nature of the study as well as provided each HP participant with a letter of information (Appendix H) and a

consent form (Appendix I) to sign prior to participating in the study. Each primary communication partner was also provided with a letter of information (Appendix J) and a consent form (Appendix K) to sign prior to participating in the study. After informed consent was obtained, each HP participant was asked to complete speech tasks and patient-reported outcome measures while seated comfortable in a quiet laboratory room. HP participants and their primary communication partners were informed that her or she would be offered to trial three different speech amplification devices at differing time periods, of one week maximum, and complete patient-reported outcome measures following the three device trial periods. The participants were informed that at the end of the three trial periods, they would be offered the opportunity to purchase and use the amplification device of their choice. The participant dyads completed all visits, described in greater detail below.

(Visit 1) Baseline. The Baseline visit consisted of a single visit to the Speech Movement Disorders Lab (Rm 2212), located in Elborn College at Western University. The Baseline visit took approximately 1-2 hours to complete. During the Baseline visit, the HP and PCP participants completed three patient reported outcome measures: the Communicative Participation Item Bank (CPIB), the Communicative Effectiveness Survey (CES), and the Voice Activity Participation Profile (VAPP). Following the completion of the three patient reported outcome measures, a hearing assessment and cognitive screening was completed, and finally, a separate experimental device evaluation was performed. The details of this experimental device evaluation are described in a previous report (see Knowles et al., 2020). Briefly, this evaluation involved having the HP participants perform two speech tasks (reading aloud sentences and describing pictures) during 8 device conditions. The device conditions included talking without a device and talking with each of the 3 devices (A, B & C) during a condition with no background noise and a condition with 65dB of multi-talker background noise. The PCP participants were also involved in this experimental device evaluation. The PCPs were asked to repeat aloud the sentences that were spoken by the HP participants in each of the 8 device conditions (the reader is referred to Knowles et al., 2020 for additional details).

(Visits 2-4) Completion of patient reported outcome measures following each of the 3 at home device trials. Following the Baseline visit, HP participants were informed that they would be given the opportunity to try out each of the three devices at home, over three separate trial periods, lasting approximately 1-week each. At this point, one of the three devices was randomly selected to be trialed first. HP participants were instructed on the basic elements of use for the device they would trial and were given a Device Diary to help them keep track of when they used the device, the context in which they used it, and any notes they would like to keep. This Device Diary was optional. Participants were instructed to try to use the device at least twice during the week and in more than one setting and with more than one person, if possible.

Following the completion of each 1-week device trial period, the participant dyads met with the primary investigator (TK) (a single visit following each 1-week device trial period). These visits lasted approximately 1 hour, at which time there was an informal discussion of the trial period and participants completed the battery of patient-reported outcome measures related to communicative participation (i.e., CES, VAPP) and the psychosocial impact of using an assistive device (i.e., PIADS). Both the HP participants and the PCP participants completed their own set of patient-reported outcome measures as described in the Baseline visit. Consistent with the Baseline visit, each HP participant was instructed to complete the series of patient-reported outcome measures from their own perspective, whereas PCP participants were instructed to complete the patient reported outcome measures in terms of how they perceived his or her partner.

Post-device period: option to purchase device. Upon the completion of all three device trial periods, the HP participants were given the option to continue using an amplification device of their choice. If participants consented, a speech-language pathologist and researcher (SA), determined eligibility for assistive device based on his assessment of the individual. If successful, a prescription for the device of his/her choice and an application for funding through the Ontario Assistive Devices Program (OADP) was submitted, which covers up to 75% of the cost of assistive communication devices up, to $400 CAD. The total cost for each device after OADP funding was applied totaled approximately $100 CAD - $250 CAD. If the participant dyads did not want to pay for

the device, they were still given the opportunity to continue trialing the device of their choosing, thus removing the potential cost barrier. Completing the study was not a prerequisite for seeking a prescription or funding for a speech amplification device.

Post-device period: device selectors versus non-selectors. All seventeen participant dyads completed all device trial sessions. Of the dyads who completed all at-home device periods, 13 (72%) selected and purchased a device for continued use after the trial-periods. This included seven (HP03, HP06, HP16, HP17, HP19, HP21, and HP22) participants who chose Device A, three participants (HP04, HP10, and HP18) who chose Device B, and three participants (HP01, HP02, and HP14) chose Device C. Five participants (HP07, HP08, HP11, HP12, and HP13) declined to take a device.

2.4 Statistical Analyses

Five main objectives were investigated in this secondary study. The first objective aimed to evaluate if ratings of communication participation differed across pre-device (baseline) versus post-device use (following the one-week trial period). The second objective aimed to evaluate the differences in self-rated communicative participation across the three devices. The third objective sought to determine if ratings of communicative participation differ for individuals with hypophonia versus their primary communication partner across device conditions. The fourth objective aimed to determine if a device hierarchy exists based on patient reported outcome measures related to communicative participation. In addition, this objective aimed to determine if this potential device hierarchy maps onto the device hierarchy proposed by Knowles et al. (2020). Finally, the fifth objective aimed to determine if final device selection is associated with patient reported outcome data obtained across the three device trial periods, categorized by device selectors versus non-selectors. These objectives will be addressed using the statistical analyses outlined below.

2.4.1. Objective 1: Evaluate if ratings of communicative participation differ across pre- versus post-device use.

2.4.1.1. Objective 1A: Evaluate if ratings obtained from the Communicative Effectiveness Survey (CES) differ across pre- versus post-device use.

Two RM ANOVAs (*Total CES and Mean CES)* and one RM MANOVA with 8 dependent variables was used to determine if there were changes in Communicative effectiveness across pre-versus post device use. There was 1 within group independent variable: “Device Condition” with 4 levels [pre-device use, post-Device A, post-Device B, post-Device C]. Communicative effectiveness item mean scores comprised the 8 dependent variables. Post-hoc evaluations focused on the following specific pre-post device condition comparisons: 1. Pre vs post-Device A; 2. Pre vs post-Device B; and 3. Pre vs post-Device C.

2.4.1.2. Objective 1B: Evaluate if ratings obtained from the Voice Activity and Participation Profile (VAPP) differ across pre- versus post- device use.

Three RM ANOVAs (*Total VAPP, ALS VAPP, PRS VAPP*) and one RM MANOVA with 4 dependent variables was used to determine if there were changes in Voice Activity and Participation Scores across pre- versus post device use. There was 1 within group independent variable: "Device Condition" with four levels [pre-device use, post-Device A, post-Device, B, post-Device C]. VAPP sub-scale scores and total score comprised all dependent variables (e.g., self-perceived severity of voice problem, effect on job, effect on daily communication, effect on social communication, effect on emotion, total VAPP score, Activity Limitation Score, Participation Restriction Score). Post-hoc evaluations focused on the following specific pre-post device condition comparisons: 1. Pre vs post-Device A; 2. Pre vs post-Device B; and 3. Pre vs post-Device C.

2.4.2. Objective 2: Evaluate if there are differences in self-rated communicative participation across the three devices.

2.4.2.1. Objective 2A: Evaluate if ratings obtained from the Communicative Effectiveness Survey (CES) differ across the three devices.

Two one-way RM ANOVAs (*Total CES*, *Mean CES*) and one RM MANOVA with 8 dependent variables was used to determine if there were changes in Communicative effectiveness scores across the three devices. There was 1 within group independent variable: "Device" with 3 levels [Device A, Device B, Device C]. Communicative effectiveness individual item mean scores comprised the 8 dependent variables.

2.4.2.2. Objective 2B: Evaluate if ratings obtained from the Voice Activity and Participation Profile (VAPP) differ across the three devices.

Three one-way RM ANOVAs (*Total VAPP*, *ALS VAPP* and *PRS VAPP*), and one RM MANOVA with 4 dependent variables was used to determine if there were changes in Voice Activity and Participation Scores across the three devices. There was 1 within group independent variable: "Device" with 3 levels [Device A, Device B, Device C]. VAPP sub-scale scores and total score comprised all dependent variables (e.g., self-perceived severity of voice problem, effect on job, effect on daily communication, effect on social communication, effect on emotion, total VAPP score, Activity Limitation Score, Participation Restriction Score).

2.4.2.3. Objective 2C: Evaluate if ratings obtained from the Psychosocial Impact of Assistive Devices Scale (PIADS) differ across the three devices.

Three one-way RM ANOVAs were used to determine if there were changes in Psychosocial Impact as a result of using an amplification device across the three devices. There was 1 within group independent variable: "Device" with 3 levels [Device A, Device B, Device C]. PIADS subscale scores comprised the dependent variables (Competence, Adaptability, Self-Esteem) in each ANOVA.

2.4.3. Objective 3: Determine if ratings of communicative participation differ for individuals with hypophonia versus their primary communication partners across device conditions.

2.4.3.1. Objective 3A: Determine if ratings obtained from the CES differed for individuals with hypophonia versus their primary communication partners across device conditions.

Two, two-factor RM ANOVAs (*Total CES* and *Mean CES*) and a single two-factor RM MANOVA was used to evaluate differences in CES scores between participants with hypophonia and their primary communication partners across the device conditions. There was 1 between group independent variable: "Group" with 2 levels [HP participants, PCP participants]. There was 1 within group independent variable: "Device" with 4 levels [no device, Device A, Device B, Device C]. Communicative effectiveness individual item mean scores comprised the 8 dependent variables.

2.4.3.2. Objective 3B: Determine if ratings obtained from the VAPP differed for individuals with hypophonia versus their primary communication partners across device conditions.

Three, two-factor RM ANOVAs (*Total VAPP*, *ALS VAPP* and *PRS VAPP*) and a single two-factor RM MANOVA was used to evaluate differences in VAPP scores between participants with hypophonia and their primary communication partners across the device conditions. There was 1 between group independent variable: "Group" with 2 levels [HP participants, PCP participants]. There was 1 within group independent variable: "Device" with 4 levels [no device, Device A, Device B, Device C]. VAPP sub-scale scores and total score comprised all dependent variables (e.g., self-perceived severity of voice problem, effect on job, effect on daily communication, effect on social communication, effect on emotion, total VAPP score, Activity Limitation Score, Participation Restriction Score).

2.4.1.3 Objective 3C: Determine if ratings obtained from the PIADS differed for individuals with hypophonia versus their primary communication partners across device conditions.

Three, two-factor RM MANOVAs with 3 dependent variables was used to evaluate differences in PIADS subscale scores between participants with hypophonia and their primary communication partners across the device conditions. There was 1 between group independent variable: “Group” with 2 levels [HP participants, PCP participants]. There was 1 within group independent variable: “Device” with 3 levels [Device A, Device B, Device C]. PIADS subscale scores comprised the 3 dependent variables (Competence, Adaptability, Self-Esteem) in each ANOVA.

2.4.4. Objective 4: Determine if a device hierarchy exists based on patient reported outcome measures related to communicative participation, and if this potential device hierarchy maps onto the device hierarchy proposed by Knowles et al. (2020) based on variables related to device preference, and performance-based objective speech measures of SNR and speech intelligibility.

2.4.4.1. Objective 4A: Determine if a device hierarchy exists based on self-rated communicative effectiveness.

Descriptive data and statistics obtained from Objective 2 will be used to determine a device hierarchy based on CES scores.

2.4.4.2. Objective 4B: Determine if a device hierarchy exists based on self-rated voice activity and participation scores.

Descriptive data and statistics obtained from Objective 2 will be used to determine a device hierarchy based on VAPP scores.

2.4.4.3. Objective 4C: Determine if a device hierarchy exists based on self-rated scores relating to the psychosocial impact of using an amplification device.

Descriptive data and statistics obtained from Objective 2 will be used to determine a device hierarchy based on PIADS scores.

2.4.5 Objective 5: Determine if final device selection is associated with patient-reported outcome data obtained in the three device trial periods.

2.4.5.1 Objective 5A: Determine if final device selection is associated with communicative effectiveness scores obtained in the four device trial periods.

Two, two-factor RM ANOVAs (*Total CES* and *Mean CES*) and a single two-factor RM MANOVA was used to compare differences between participant dyads who purchased a device (selectors) versus participant dyads who opted to not purchase a device (non-selectors) based on device and CES scores. There was one between group independent variable: "Group" with two levels [selectors, non-selectors]. There was one within group independent variable: "Device" with 4 levels [pre-device, Device A, Device B, Device C]. Communicative effectiveness individual item mean scores comprised the 8 dependent variables.

2.4.5.2 Objective 5B: Determine if final device selection is associated voice activity and participation scores obtained in the four device trial periods.

Three, two-factor RM ANOVAs (*Total VAPP, ALS VAPP* and *PRS VAPP*) and a two-factor RM MANOVA was used to compare differences between participant dyads who purchased a device (selectors) versus participant dyads who opted to not purchase a device (non-selectors) based on device and VAPP scores. There was one between group independent variable: "Group" with two levels [selectors, non-selectors]. There was one within group independent variable: "Device" with 4 levels [pre-device, Device A, Device B, Device C]. VAPP sub-scale scores and total score comprised all dependent variables (e.g., self-perceived severity of voice problem, effect on job, effect on daily communication, effect on social communication, effect on emotion, total VAPP score, Activity Limitation Score, Participation Restriction Score).

2.4.5.3 Objective 5C: Determine if final device selection is associated with scores related to the psychosocial impact of using an amplification device in the three device trial periods.

Three two-factor RM ANOVAs were used to compare differences between participant dyads who purchased a device (selectors) versus participant dyads who opted to not purchase a device (non-selectors) based on device and PIADS scores. There was one between group independent variable: “Group” with two levels [selectors, non-selectors]. There was one within group independent variable: “Device” with 3 levels [Device A, Device B, Device C]. PIADS subscale scores comprised the 3 dependent variables (Competence, Adaptability, Self-Esteem) in each ANOVA.

Chapter 3

3 Results

3.1 Statistical Power

Statistical power reflects the prospect of identifying differences resulting from a treatment and probability of the successful replication of a study (Keppel, 1991). Statistical power is established based on the interaction and relationships among sample size, variance within data, effect size and statistical significance (Portney & Watkins, 2000). G*Power v3.1 (Faul, Erdfelder, Lang, & Buchner, 2007) was used to perform the power analysis.

The power calculations were based on the findings of previous studies exploring communicative effectiveness and treatment transfer (Ramig et al., 2018). Based on previous studies, the effect size for Ramig and colleagues' study (2018) was approximately 1, with an overall alpha of 0.05 and considering three multiple comparisons, two-tailed tests; 20 participants were required per group to yield 80% power.

Using the proposed 17 participant dyads, an alpha level of .017 (based on .05/3 pairwise comparisons of 3 devices and 1 pre-device condition), and an effect size of 0.8 of a standard deviation between the device means, it is estimated that the current secondary study will have a power of .82.

3.2 Reliability

Inter-rater estimates of reliability were calculated for ratings obtained from the Voice Activity Participation Profile across the device trial periods. The ICC values obtained during the device periods ranged from 1 to 1, $p<0.001$. These ICC values demonstrate overall excellent reliability between raters when scoring this patient reported outcome measure.

Scores measured/calculated by the secondary investigator (JS) were measured against scores measured by the primary investigator (TK) to obtain inter-rater reliability values.

The secondary investigator (JS) re-measured/re-calculated 20% of the patient-reported outcome data to determine intra-rater reliability. Cronbach's alpha revealed an overall intra-rater reliability estimate of 1, $p<0.001$ across the patient-reported outcome measure, which indicates excellent intra-rater reliability across all task measurements.

Table 2 summarizes the interclass correlation coefficient and Cronbach's alpha values in obtaining overall inter-rater and intra-rater reliability values. Table 3 summarizes the descriptive statistics and the results of interclass coefficient analyses used to obtain intra-rater estimates of reliability. Statistical output of the overall inter-rater reliability analyses can be found in Appendix L. Statistical output of the overall intra-rater reliability analyses can be found in Appendix M.

Table 2

Summary of intra-rater and inter-rater estimates of reliability across VAPP measurements.

	Intra-rater Reliability	**Inter-rater Reliability**
Intra-class correlation coefficient (ICC)	**1 p<0.01**	**1 p<0.01**
Cronbach's alpha	**1**	**1**

Table 3

Summary of descriptive statistics and the results of inter-rater estimates of reliability for the VAPP across all device trial periods.

	Rater 1	**Rater 2**	**ICC**	**Cronbach's alpha**
VAPP	4838.3	4842.7	1 p<0.001	1

3.3 Objective 1: To evaluate if ratings of communicative participation differ across pre-versus post-device use.

The purpose of this objective was to evaluate ratings of communicative participation before and after device trials. Specifically, the aim of this objective was to determine if

there were any differences in self-rated communicative effectiveness and voice activity and participation among the participants with hypophonia before device use and after device trials.

3.3.1 Objective 1A: Communicative Effectiveness.

Two repeated measures one-factor ANOVAs and one repeated measures MANOVA were conducted to evaluate differences in self-rated communicative effectiveness based on device condition.

Repeated Measures ANOVAs. The first RM ANOVA was based on *Total CES* scores, and the second RM ANOVA was based on *Mean CES* scores. For the first analysis, the dependent variable was "*Total CES*" and for the second analysis, the dependent variable was "*Mean CES.*" For both analyses, there was one within-group factor, "*Device Condition*" with four levels [pre-Device use, post-Device A, post-Device B, and post Device-C].

Total CES scores. The first analysis which was based on *Total CES* scores revealed a statistically significant difference of *Total CES* scores across the within-group factor "*Device Condition*" $F(3, 48)=3.66$, $p=0.019$. This result suggests participants with hypophonia rated themselves as less effective communicators ($M=17.76$, $SD=5.90$) in the pre-device condition and more effective communicators after trialing all devices (Device A: $M=21.18$, $SD=3.67$; Device B: $M=22.18$, $SD=4.57$; Device C: $M=21.53$, $SD=4.28$).

To examine these differences in greater detail, post hoc comparisons using the LSD method were completed to determine if there were differences in *Total CES* scores based on specific comparisons across the device conditions. The post hoc comparisons indicated that the *Total CES* score for the 'pre-Device' condition ($M=17.76$, $SD=5.90$) was not significant ($p=0.072$) for Device A ($M=21.18$, $SD=3.67$). The post hoc comparisons of *Total CES* score indicated that the 'pre-Device' condition was significantly lower ($p=0.017$) than the 'post-Device B' condition ($M=22.18$, $SD=4.57$) and significantly lower ($p=0.029$) than the 'post-Device C' condition ($M=21.53$, $SD=4.28$). These results suggest when comparing pre-post values for overall total self-

rated communicative effectiveness scores, Device B and Device C were significant. Table 4 presents the descriptive statistics for the one-factor RM ANOVA analysis based on *Total CES* scores and is represented graphically in Figure 1.

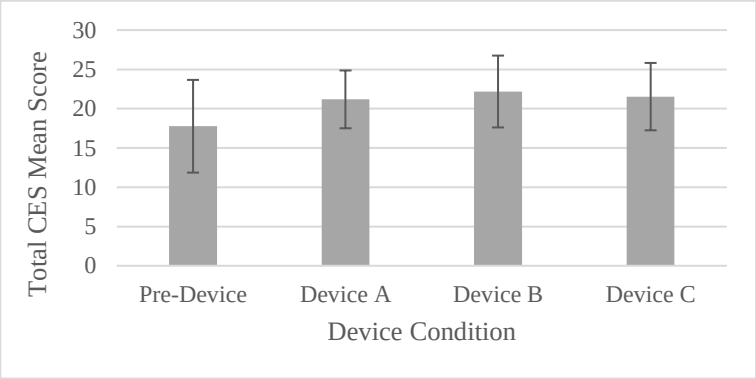
Table 4

Descriptive statistics for Total CES in each device condition

Device Condition	N	Mean (SD)
Pre-Device	17	17.76 (5.90)
Device A	17	21.18 (3.67)
Device B	17	22.18 (4.57)
Device C	17	21.53 (4.28)

Figure 1

Total CES mean scores based on device condition
Standard deviations are expressed as Error Bars



Mean CES scores. The second analysis which was based on *Mean CES total* score revealed a statistically significant difference of *Mean CES* scores across the within-group factor "*Device Condition*" $F(3, 48)=3.66$, $p=0.019$. This result suggests participants with hypophonia rated themselves as less effective communicators ($M=2.22$, $SD=0.73$) in the pre-device condition and more effective communicators in after trialing all devices (Device A: $M=2.64$, $SD=0.45$; Device B: $M=2.77$, $SD=0.57$; Device C: $M=2.69$, $SD=0.53$) based on the Mean CES score.

To examine these differences in greater detail, post hoc comparisons using the LSD (least significant difference) method, were run to determine if there were differences in *Mean*

CES total scores based on specific comparisons across the device conditions. The post hoc comparisons indicated that the *Mean CES* score for the 'pre-Device' condition (*M*=2.22, *SD*=0.73) was not significant (*p*=0.072) for Device A (*M*=2.64, *SD*=0.45). The post hoc comparisons of *Mean CES* score for the 'pre-Device' condition was significantly lower (*p*=0.017) than the 'post-Device B' condition (*M*=2.77, *SD*=0.57) and significantly lower (*p*=0.029) than the 'post-Device C' condition (*M*=2.69, *SD*=0.53). These results suggest when comparing pre-post values for self-rated communicative effectiveness mean scores, Device B and Device C were significant. Table 5 presents the descriptive statistics for the one-factor RM ANOVA analysis based on *Mean CES* scores and is represented graphically in Figure 2.

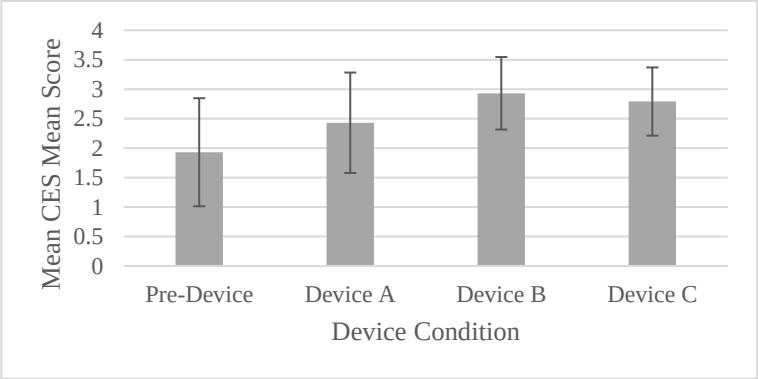
Table 5

Descriptive statistics for Mean CES in each device condition

Device Condition	N	Mean (SD)
Pre-Device	17	2.22 (.73)
Device A	17	2.64 (.45)
Device B	17	2.77 (.57)
Device C	17	2.69 (.53)

Figure 2

Mean CES scores based on device condition
Standard deviations are expressed as Error Bars



RM MANOVA. A repeated measures one-factor MANOVA was conducted to examine if there were differences across the device conditions (pre-device use vs post-device use) based on the eight individual questions contained on the CES. There was one-

within group factor "*Device Condition*" with four levels [pre-Device use, post-Device A, post-Device B, post-Device C]. The individual questions on the CES served as the eight dependent variables [Q1CES, Q2CES, Q3CES, Q4CES, Q5CES, Q6CES, Q7CES, Q8CES].

Results of the one-factor RM MANOVA revealed a significant main effect of "*Device Condition*" based on the eight CES questions, $F(24, 93)=2.16$, $p=0.004$, $\eta^2_{partial} = 0.348$. Given the significance of the multivariate statistic, the univariate main effects were examined. A significant univariate main effect was found for CES question 5: "*Being part of a conversation in a noisy environment*", $F(3, 39)=5.88$, $p=0.002$, $\eta^2_{partial} = 0.312$. This result suggests that participants with hypophonia self-rated less effective communication in noise pre-device use ($M=1.93$, $SD=0.91$) versus post-device use (Device A: $M=2.43$, $SD=0.85$; Device B: $M=2.93$, $SD= 0.61$; Device C: $M=2.79$, $SD=0.57$) (Table 7). A significant univariate main effect was also found for question 7 on the CES: "*Having a conversation while traveling in a car*", $F(3, 39)=2.95$, $p=0.044$, $\eta^2_{partial} = 0.185$. This result suggests that participants with hypophonia self-rated less effective communication while traveling in a vehicle pre-device use ($M=2.21$, $SD=0.97$) versus post-device use (Device A: $M=2.86$, $SD=0.66$; Device B: $M=2.79$, $SD=0.80$; Device C: $M=3.00$, $SD=0.78$) (Table 7). Finally, a significant univariate effect was found for question 8 on the CES: "*Having a conversation with someone at a distance*", $F(3, 39)=11.14$, $p=0.000$, $\eta^2_{partial} = 0.462$. This result suggests that participants with hypophonia self-rated less effective communication when conversing at an increased interlocuter distance pre-device use ($M=2.07$, $SD=0.91$) versus post-device use (Device A: $M=2.72$, $SD=0.82$; Device B: $M=3.36$, $SD=0.84$; Device C: $M=3.39$, $SD=0.46$) (Table 7). Univariate main effects did not reach significance for CES questions 1, 2, 3, 4 and 6. The univariate statistics are presented in Table 6 for each of the eight CES questions and

the descriptive statistics are presented in Table 7. The detailed results of this single-factor repeated measures MANOVA analysis is presented in Appendix N.

Table 6

Effect of Device Condition (pre-Device use versus post-Device use) based on CES items Q1-Q8

Device Condition CES Items	***F*(3, 39)**	***p***	$\eta^2_{partial}$
Q1	.37	.772	.028
Q2	.81	.496	.059
Q3	1.32	.281	.092
Q4	1.56	.214	.107
Q5	5.88	.002	.312
Q6	2.67	.060	.171
Q7	2.95	.044	.185
Q8	11.14	.000	.462

Table 7

Descriptive statistics related to the RM MANOVA for CES items Q1-Q8

Device Condition (pre-post) CES items	**N**	**Mean (SD)**	**Device Condition (pre-post) CES items**	**N**	**Mean (SD)**
Q1 Pre-Device	14	2.93 (.73)	Q5 Pre-Device	14	1.93 (.91)
Q1 Device A	14	3.14 (.66)	Q5 Device A	14	2.43 (.85)
Q1 Device B	14	3.14 (.77)	Q5 Device B	14	2.93 (.61)
Q1 Device C	14	3.21 (.69)	Q5 Device C	14	2.79 (.57)
Q2 Pre-Device	14	2.43 (.93)	Q6 Pre-Device	14	2.00 (.87)
Q2 Device A	14	2.79 (.69)	Q6 Device A	14	2.14 (.94)
Q2 Device B	14	2.86 (.86)	Q6 Device B	14	2.64 (.92)
Q2 Device C	14	2.71 (.91)	Q6 Device C	14	2.71 (.61)
Q3 Pre-Device	14	2.57 (.93)	Q7 Pre-Device	14	2.21 (.97)
Q3 Device A	14	2.64 (.74)	Q7 Device A	14	2.86 (.66)
Q3 Device B	14	2.86 (.53)	Q7 Device B	14	2.79 (.80)
Q3 Device C	14	2.21 (1.05)	Q7 Device C	14	3.00 (.78)
Q4 Pre-Device	14	2.29 (1.13)	Q8 Pre-Device	14	2.07 (.91)
Q4 Device A	14	2.36 (.63)	Q8 Device A	14	2.71 (.82)
Q4 Device B	14	2.57 (.51)	Q8 Device B	14	3.36 (.84)
Q4 Device C	14	1.93 (.99)	Q8 Device C	14	3.29 (.46)

Note. N=14; Three HP participants were not included in this analysis due to incompletion of the CES for at least one of the devices

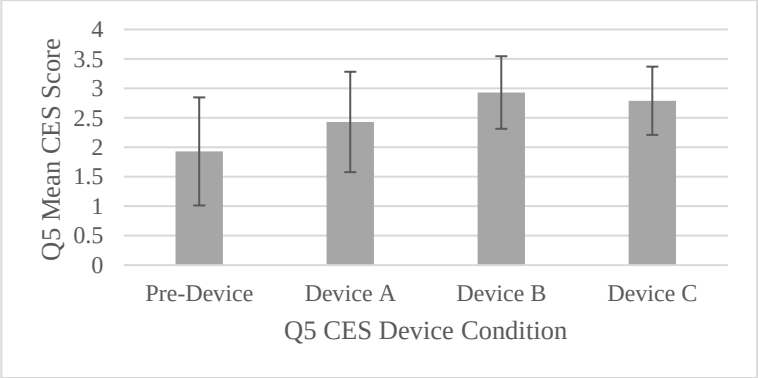
Post hoc comparisons. Post hoc comparisons using the LSD method, were completed for the CES questions with significant univariate main effects (CES questions 5,7,8) to determine the differences based on specific devices. The post hoc analyses

focused on the following three comparisons: 1. pre-Device versus post-Device A, 2. pre-Device versus post-Device B, and 3. pre-Device versus post-Device C).

CES Q5: Being part of a conversation in a noisy environment (social gathering). The LSD post hoc comparisons of the pre-device versus post-device conditions related to Q5CES indicated that the mean Q5CES score for the 'pre-device' condition (*M*=1.93, *SD*=0.91) was significantly lower (*p*=0.005) than the 'post-device B' condition (*M*=2.93, *SD*=0.61) and significantly lower (*p*=0.017) than the 'post-device C' condition (*M*=2.79, *SD*=0.57). The post hoc comparison of the 'pre-device' condition did not reach significance (*p*=0.110) for the 'post-device A' condition (*M*=2.42, *SD*=0.82). This result suggests participants with hypophonia rated themselves as more effective communicating in noise when trialing both Device B and Device C in comparison to the pre-device condition. Please see Figure 3 for a graphic representation of these results.

Figure 3

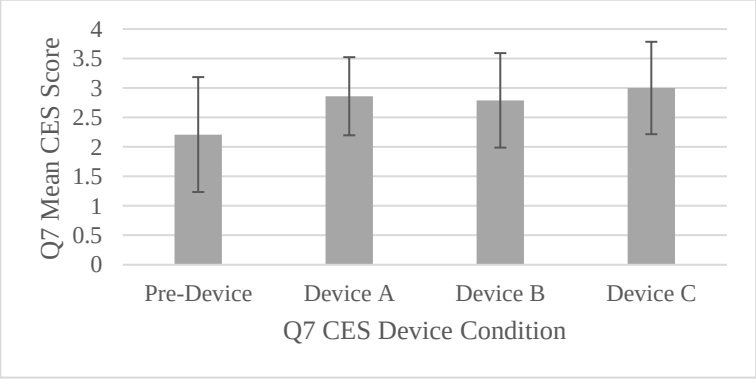
Q5 CES mean scores based on device condition
Standard deviations are expressed as Error Bars



*CES Q7: Having a conversation while traveling in a car***.** The LSD post hoc comparison of the pre-device versus post-device conditions related to Q7 CES indicated that the mean Q7CES score for the 'pre-device' condition (*M*=2.21, *SD*=0.97) was significantly lower (*p*=0.033) than the 'post-device A' condition (*M*=2.86, *SD*=0.66) and the 'post-device C' condition (*M*=3.00, *SD*=0.78; *p*=0.028). The post hoc comparison of the 'pre-device' condition did not reach significance (*p*=0.104) for the 'post-device B' condition (*M*= 2.79, *SD*=0.80). This result suggests participants with hypophonia rated themselves as more effective communicating in a vehicle when trialing both Device A and Device C in comparison to the pre-device condition. Figure 4 presents a graphic representation of these results.

Figure 4

Q7 CES mean scores based on device condition
Standard deviations are expressed as Error Bars

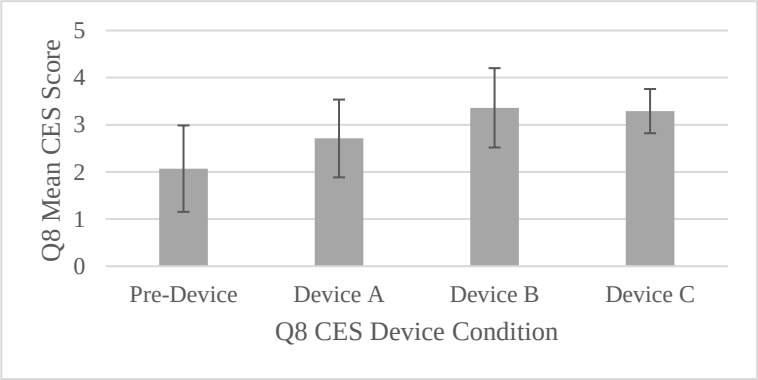


CES Q8: Having a conversation with someone at a distance (across a room). The post hoc comparison of the pre-device versus post-device conditions based on Q8CES indicated that the mean Q8CES score for the 'pre-device' condition (*M*=2.07, *SD*=0.91) was significantly lower (*p*=0.001) than the 'post-device B' condition (*M*=3.36, *SD*=0.84), and the 'post-device C' condition (*M*=3.29, *SD*=0.46; *p* =0.000). The post hoc comparison of the 'pre-device' condition did not reach significance (*p*=0.057) for the 'post-device A' condition (*M*=2.71, *SD*=0.82). This result suggests participants with hypophonia rated themselves as more effective communicating at an increased

interlocuter distance when trialing both Device B and Device C in comparison to the pre-device condition. Figure 5 provides a graphic representation of these results.

Figure 5

Q8 CES mean scores based on device condition
Standard deviations are expressed as Error Bars



Taken together, these three CES questions (Q5CES: *Being a part of a conversation in a noisy environment*, Q7CES: *Having a conversation while travelling in a car*, and Q8CES: *Having a conversation with someone at a distance*), may be capturing pre-post device effects associated with these specific communicative contexts related to communicative effectiveness. The interpretation of these results and the potential importance of these questions will be expanded upon in the Discussion.

3.3.2 Objective 1B: Voice Activity and Participation.

Three repeated measures one-factor ANOVAs and one repeated measures MANOVA were conducted to evaluate differences in voice activity and participation based on device condition.

Repeated Measures ANOVAs. The first RM ANOVA was based on *Total VAPP* scores, the second RM ANOVA was based on the VAPP *ALS (Activity Limitation Score)*, and the third RM ANOVA was based on the VAPP *PRS (Participation Restriction Score*). For the first analysis, the dependent variable was "*Total VAPP,*" the second analysis, the dependent variable was "*VAPP ALS,*" and the third analysis, the dependent variable was "*VAPP PRS"* For all three analyses, there was one within-group factor,

"*Device Condition*" with four levels [pre-Device use, post-Device A, post-Device B, and post Device-C].

Total VAPP score. The first analysis which was based on the *Total VAPP* score revealed a statistically significant difference of *Total VAPP* scores across the within-group factor "*Device Condition*", $F(3, 45)=17.56$, $p=0.000$. This result suggests participants with hypophonia rated themselves as having reduced voice activity and participation ($M=145.80$, $SD=50.49$) in the pre-device condition and reported increased voice activity and participation after trialing all devices (Device A: $M=81.43$; $SD=41.57$; Device B: $M=86.04$, $SD=51.75$; Device C: $M=77.89$, $SD=28.32$). Please note that higher VAPP scores represent more limitations and restrictions and lower VAPP scores represent less limitations and restrictions to activity and participation, respectively.

To examine these differences, post hoc comparisons using the LSD method were completed to determine if there were differences in *Total VAPP* scores based on specific comparisons across the device conditions. The post hoc comparisons indicated that the *Total VAPP* score for the 'pre-device' condition ($M=145.80$, $SD=50.49$) was significantly higher ($p=0.000$) than the 'post-device A' condition ($M=81.43$, $SD=41.57$), significantly higher ($p=0.001$) than the 'post-device B' condition ($M=86.04$, $SD=51.75$) and significantly higher ($p=0.000$) than the 'post-device C' condition ($M=77.89$, $SD=28.32$). This result suggests prior to trialing the amplification devices, individuals with hypophonia reported higher total VAPP scores, indicating increased voice activity limitations and participation restrictions than after trialing all the devices. Table 8 presents the descriptive statistics for the one-factor RM ANOVA analysis based on *Total VAPP* scores and is represented graphically in Figure 6.

Table 8

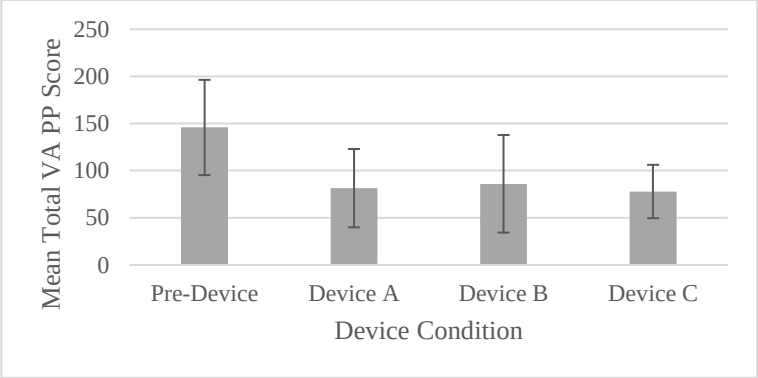
Descriptive statistics for Total VAPP in each device condition

Device Condition	N	Mean (SD)
Pre-Device	16	145.80 (50.49)
Device A	16	81.43 (41.57)
Device B	16	86.04 (51.75)
Device C	16	77.89 (28.32)

Note. N=16; One HP participant was not included in this analysis due to incompletion of the VAPP for Device B

Figure 6

Total VAPP mean scores based on device condition
Standard deviations are expressed as Error Bars



VAPP ALS. The second analysis which was based on the *VAPP ALS* score revealed a statistically significant difference across '*Device Condition' F*(3, 45)=20.66, *p*=0.000. This result suggests participants with hypophonia rated themselves as having more activity limitations (*M*=14.01, *SD*=5.16) in the pre-device condition and less activity limitations after trialing all devices (Device A: *M*=6.23, *SD*=3.87; Device B: *M*=6.91, *SD*=5.01; Device C: *M*=6.42, *SD*=2.93).

To examine these differences, the LSD post hoc comparisons were completed to determine if there were differences in *VAPP ALS* scores based on specific comparisons across the device conditions. The post hoc comparisons indicated that the VAPP activity limitation score for the 'pre-device' condition (*M*=14.01, *SD*=5.16) was significantly higher (*p*=0.000) than the 'post-device A' condition (*M*=6.23, *SD*=3.87), the 'post-device B' condition (*M*=6.91, *SD*=5.01, *p*=0.000) and the 'post-device C' condition (*M*=6.42, *SD*=2.93, *p*=0.000). This result suggests prior to trialing the amplification devices,

individuals with hypophonia reported more activity limitations, compared to after trialing any of the three devices. Table 9 presents the descriptive statistics for the one-factor RM ANOVA analysis based on *VAPP ALS* and is represented graphically in Figure 7.

Table 9

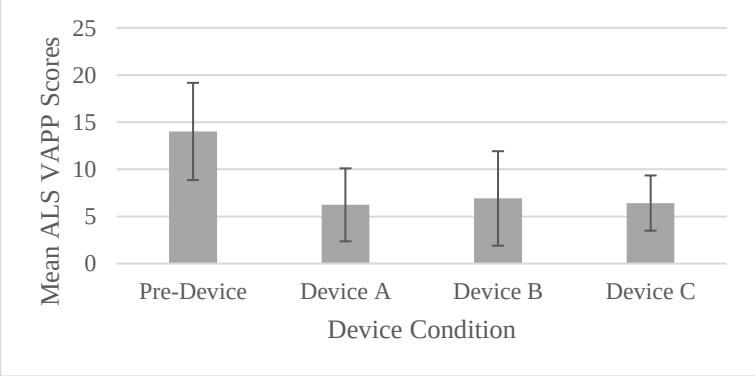
Descriptive statistics for VAPP ALS in each device condition

Device Condition	N	Mean (SD)
Pre-Device	16	14.01 (5.16)
Device A	16	6.23 (3.87)
Device B	16	6.91 (5.01)
Device C	16	6.42 (2.93)

Note. N=16; One HP participant was not included in this analysis due to incompletion of the VAPP for Device B

Figure 7

Mean VAPP ALS based on device condition
Standard deviations are expressed as Error Bars



VAPP PRS. The third analysis which was based on the *VAPP PRS* score revealed a statistically significant difference across "*Device Condition" F*(3, 45)=14.91, *p*=0.000. This result suggests participants with hypophonia rated themselves as having greater participation restrictions (*M*=12.23, *SD*=5.56) in the pre-device condition and less participation restrictions after trialing all devices (Device A: *M*=5.34, *SD*=4.15; Device B: *M*=7.22, *SD*=5.93; Device C: *M*=5.40, *SD*=3.08).

To examine these differences, LSD post hoc comparisons were completed to determine if there were differences in *VAPP PRS* scores based on specific comparisons across the device conditions. The post hoc comparisons indicated that the PRS score for the 'pre-device' condition (*M*=12.23, *SD*=5.56) was significantly higher (*p*=0.000) than the 'post-

device A' condition (*M*=5.34, *SD*=4.15), the 'post-device B' condition (*M*=7.22, *SD*=5.93, *p*=0.003) and the 'post-device C' condition (*M*=5.40, *SD*=3.09, *p*=0.000). This result suggests prior to trialing the amplification devices, individuals experienced more restrictions to participation. Table 10 presents the descriptive statistics for the one-factor RM ANOVA analysis based on the *VAPP PRS* score and is represented graphically in Figure 8.

Table 10

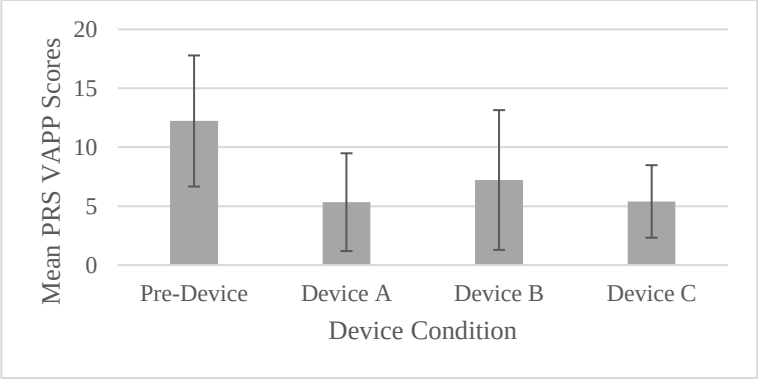
Descriptive statistics for VAPP PRS in each device condition

Device Condition	N	Mean (SD)
Pre-Device	16	12.23 (5.56)
Device A	16	5.34 (4.15)
Device B	16	7.22 (5.93)
Device C	16	5.40 (3.08)

Note. N=16; One HP participant was omitted from analysis due to incompletion of the VAPP for Device B

Figure 8

Mean VAPP PRS based on device condition
Standard deviations are expressed as Error Bars



RM MANOVA. A repeated measures one-factor MANOVA was conducted to examine if there were differences across the device conditions [pre-device use vs post-device use (combined)] based on the subscale categories on the VAPP. There was one-within group factor "*Device Condition*" with four levels [pre-Device use, post-Device A, post-Device B, post-Device C]. The subscale categories on the VAPP (Category 1: *Self-perceived severity of voice problem*; Category 3: *Effect on daily communication*; Category 4: *Effect on social communication*; Category 5: *Effect on emotion*) served as the

four dependent variables labeled as [C1VAPP, C3VAPP, C4VAPP, C5VAPP]. Although there is a total of five subscale categories on the VAPP, Category 2: *Effect on job*, was omitted because most HP participants were not employed because they were retired. See Table 11 for descriptive statistics obtained for each device condition based on the RM ANOVA analysis.

Table 11

Descriptive statistics for pre-post Device conditions based on VAPP subscale category scores

Device Condition VAPP subscale categories	**N**	**Mean (SD)**
C1 Pre-Device	16	6.16 (2.41)
C1 Device A	16	3.20 (1.99)
C1 Device B	16	3.82 (2.57)
C1 Device C	16	3.60 (2.08)
C3 Pre-Device	16	74.33 (22.19)
C3 Device A	16	38.79 (20.33)
C3 Device B	16	40.43 (26.59)
C3 Device C	16	39.01 (16.64)
C4 Pre-Device	16	20.76 (9.62)
C4 Device A	16	12.59 (8.62)
C4 Device B	16	12.81 (9.48)
C4 Device C	16	11.82 (6.70)
C5 Pre-Device	16	42.06 (16.95)
C5 Device A	16	26.83 (17.71)
C5 Device B	16	28.96 (18.43)
C5 Device C	16	23.45 (11.94)

Note. N=16; One HP participant was not included in this analysis due to incompletion of the VAPP for Device B

Results of the one-factor RM MANOVA revealed a significant main effect for "*Device Condition*" on the four VAPP subscale category questions, $F(12, 111)=3.865$, $p=0.000$, $\eta^2_{partial}=0.264$. Based on the significant multivariate statistic, the separate univariate main effects of the four VAPP subscale categories were examined. Table 12 presents the univariate results of the RM MANOVA of this objective. Significant univariate effects were found for the mean scores of each of the VAPP subscale categories based on "Device Condition."

A significant univariate main effect was found for subscale Category 1: "*Self- perceived severity of voice problem", $F(3, 45)=8.42$, $p=0.000$, $\eta^2_{partial}=0.360$.* This result suggests that participants with hypophonia self-rated greater severity of their voice problem pre-device use ($M=6.16$, $SD=2.41$) versus post-device use (Device A: $M=3.20$, $SD=1.99$;

Device B: *M*=3.82, *SD*= 2.57; Device C: *M*=3.60, *SD*=2.08) (Table 11). A significant univariate main effect was found for subscale Category 3: "*Effect on daily communication*", $F(3, 45)=18.78$, $p=0.000$, $\eta^2_{partial}=0.556$. This result suggests that participants with hypophonia self-rated a greater negative effect on daily communication pre-device use (*M*=74.33, *SD*=22.19) versus post-device use (Device A: *M*= 38.79, *SD*=20.33; Device B: *M*=40.43, *SD*= 26.59; Device C: *M*=39.01, *SD*=16.64) (Table 11). A significant univariate main effect was found for subscale Category 4, "*Effect on social communication*", $F(3, 45)=27.53$, $p=0.000$, $\eta^2_{partial}=0.334$. This result suggests that participants with hypophonia self-rated a greater negative effect on social communication pre-device use (*M*=20.76, *SD*=9.62) versus post-device use (Device A: *M*=12.59, *SD*=8.62; Device B: *M*=12.81 *SD*=9.48; Device C: *M*=11.82, *SD*=6.70) (Table 11). A significant univariate main effect was also found for VAPP subscale Category 5, "*Effect on emotion*", $F(3, 45)=8.24$, $p=0.000$, $\eta^2_{partial}=0.355$. This result suggests that participants with hypophonia self-rated a greater negative effect on emotion pre-device use (*M*=42.06, *SD*=16.95) versus post-device use (Device A: *M*=26.83, *SD*=17.71; Device B: *M*=28.96, *SD*=18.43; Device C: *M*=23.45, *SD*=11.94) (Table 11). The detailed results of this repeated measures MANOVA analysis are presented in Appendix O.

Table 12

Effect of Device Condition (pre-Device use versus post-Device use) based on VAPP subscale category items

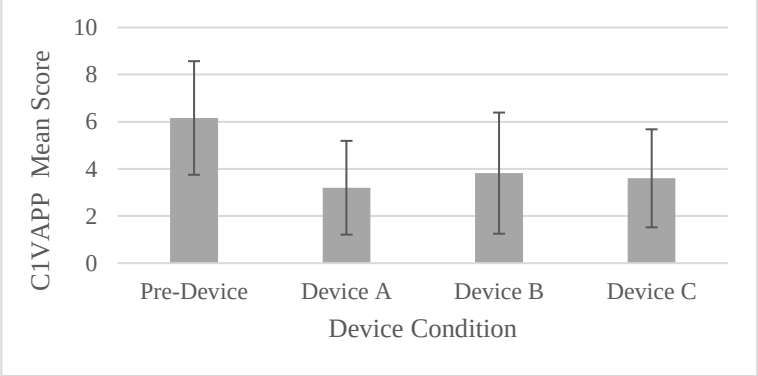
Device Condition VAPP subscale categories	***F*(3, 45)**	***p***	$\eta^2_{partial}$
C1	8.42	.000	.360
C3	18.78	.000	.556
C4	7.53	.000	.334
C5	8.24	.000	.355

Post hoc comparisons. LSD post hoc comparisons were completed for the VAPP sub-scale categories with significant univariate main effects (VAPP subscale categories 1,3,4,5) to determine the differences based on specific devices. The post hoc analyses focused on the following three comparisons: 1. pre-Device versus post-Device A, 2. pre-Device versus post-Device B, and 3. pre-device versus post-Device C.

VAPP C1: Self- perceived severity of voice problem. The post hoc comparisons related to C1VAPP, indicated that the mean C1VAPP score for the 'pre-device' condition (*M*=6.16, *SD*=2.41) was significantly higher (*p*=0.001) than the 'post-device A' condition (*M*=3.20, *SD*=1.99), 'post-device B' condition (*M*=3.82, *SD*=2.57, *p*=0.002), and 'post-device C' condition (*M*=3.60, *SD*=2.08, *p*=0.000). These results suggest that individuals with hypophonia perceived their voice problem to be more severe before trialing the three devices as compared to after trialing any of the three devices. The RM MANOVA results for the C1VAPP subscore is presented in Figure 9.

Figure 9

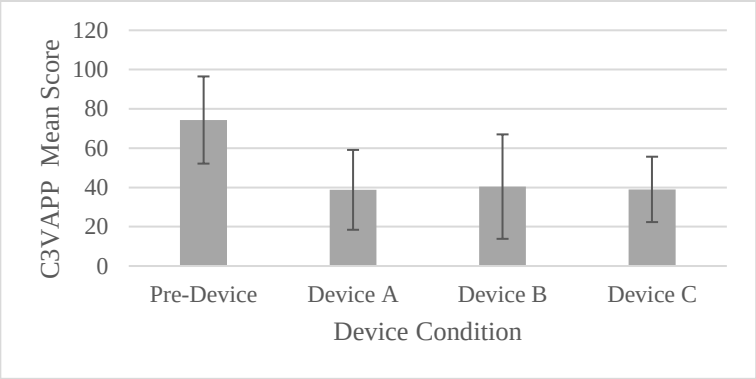
C1VAPP mean scores based on device condition
Standard deviations are expressed by Error Bars



VAPP C3: Effect on daily communication. The post hoc comparisons related to C3VAPP, indicated that the C3VAPP mean score for the 'pre-device' condition (*M*=74.33, *SD*=22.19) was significantly higher (*p*=0.000) than the 'post-device A' condition (*M*=38.79, *SD*=20.33), 'post-device B' condition (*M*=40.43, *SD*=26.59, *p*=0.000), and 'post-device C' condition (*M*=39.01, *SD*=16.64, *p*=0.000). These results suggest individuals with hypophonia reported that their voice problem had less of an effect on their daily communication after trialing any of the three amplification devices, compared to before device use. The RM MANOVA results for the C3VAPP subscale is presented in Figure 10.

Figure 10

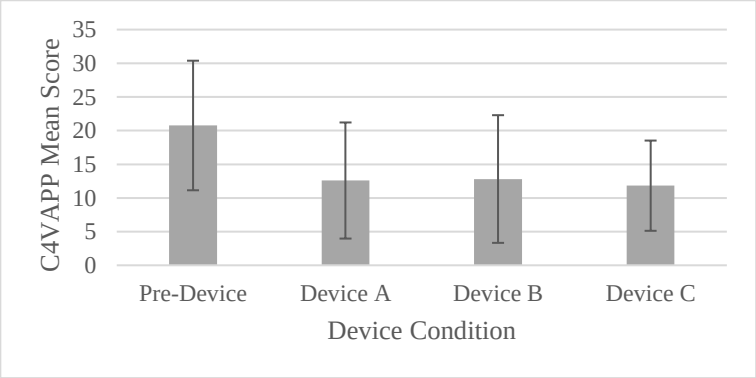
C3VAPP mean scores based on device condition
Standard deviations are expressed by Error Bars



VAPP C4: Effect on social communication. The post hoc comparisons for C4VAPP, indicated that the C4VAPP mean score for the 'pre-device' condition (*M*=20.76, *SD*=9.62) was significantly higher (*p*=0.005) than the 'post-device A' condition (*M*=12.59, *SD*=8.62), 'post-device B' condition (*M*=12.81, *SD*=9.48, *p*=0.006), and 'post-device C' condition (*M*=11.82, *SD*=6.70, *p*=0.001). These results suggest that individuals with hypophonia rated their voice problem as having a lesser effect on their social communication after trialing any of the three amplification devices as compared to before device use. The RM MANOVA results for the C4VAPP subscale is presented in Figure 11.

Figure 11

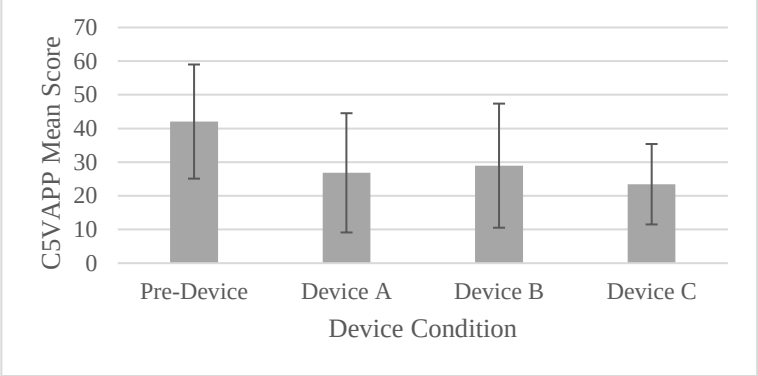
C4VAPP mean scores based on device condition
Standard deviations are expressed by Error Bars



VAPP C5: Effect on emotion. The post hoc comparisons for C5VAPP, indicated that the C5VAPP mean score for the 'pre-device' condition (*M*=42.06, *SD*=16.95) was significantly higher (*p*=0.001) than the 'post-device A' condition (*M*=26.83, *SD*=17.71), 'post-device B' condition (*M*=28.96, *SD*=18.43, *p*=0.018), and 'post-device C' condition (*M*=23.45, *SD*=11.94, *p*=0.000). These results suggest that individuals with hypophonia rated their voice problem as having less of an effect on their emotion after trialing any of the three amplification devices as compared to before device use. The RM MANOVA results for the C5VAPP subscale is presented in Figure 12.

Figure 12

C5VAPP mean scores based on device condition
Standard deviations are expressed by Error Bars



Taken together, these VAPP subscale categories (*Self- perceived severity of voice problem, Effect on daily communication, Effect on social communication,* and *Effect on emotion*), may be capturing pre-post device effects for improving voice activity and participation, regardless of the device trialed. The interpretation of the potential importance of these findings will be further discussed in the Discussion.

3.4 Objective 2: To evaluate if there are differences in self-rated communicative participation across the three devices.

The purpose of this objective was to evaluate if there were differences in self-rated communicative participation across the three amplification devices. Specifically, the aim of this objective was to determine if there were any differences in ratings of

communicative effectiveness, voice activity and participation, as well as the psychosocial impact of device use, across the three devices among the participants with hypophonia.

3.4.1 Objective 2A: Communicative Effectiveness.

Two RM ANOVAs and one repeated measures MANOVA were conducted to evaluate differences in self-rated communicative effectiveness across device conditions.

Repeated Measures ANOVAs. The first RM ANOVA was based on *Total CES* scores, and the second RM ANOVA was based on *Mean CES* scores. For the first analysis, the dependent variable was "*Total CES*" and for the second analysis, the dependent variable was "*Mean CES.*" For both analyses, there was one within-group factor, "*Device Condition*" with three levels [post-Device A, post-Device B, and post Device-C].

Total CES scores. The first analysis which was based on *Total CES* scores did not reveal a statistically significant difference of *Total CES* scores across the within-group factor "*Device Condition*" $F(2, 32)=0.348$; $p=0.709$. This result suggests that participants with hypophonia did not self-rate communicative effectiveness significantly different across the three devices (Device A: $M=21.18$, $SD=3.67$; Device B: $M=22.18$, $SD=4.57$; Device C: $M=21.53$, $SD=4.28$) (Table 13). Table 13 presents the descriptive statistics for the one-factor ANOVA based on *Total CES* scores.

Table 13

Descriptive statistics for Total CES scores based on device

Device Condition	N	Mean (SD)
Device A	17	21.18 (3.67)
Device B	17	22.18 (4.57)
Device C	17	21.53 (4.28)

Mean CES scores. The second analysis which was based on *Mean CES* total score did not reveal a statistically significant difference of *Mean CES* scores across the within-group factor "*Device Condition*" $F(2, 32)=0.348$; $p=0.709$.This result suggests that participants with hypophonia did not self-rate communicative effectiveness significantly different across the three devices based on the Mean CES score (Device A: $M=2.64$,

SD=0.459; Device B: *M*=2.77, *SD*=0.571; Device C: *M*=2.69, *SD*=0.536) (Table 14). Table 14 presents the descriptive statistics for the one-factor ANOVA based on *Mean CES* scores.

Table 14

Descriptive statistics for Mean CES scores based on device

Device Condition	N	Mean (SD)
Device A	17	2.64 (.45)
Device B	17	2.77 (.57)
Device C	17	2.69 (.53)

RM MANOVA. A repeated measures one-factor MANOVA was conducted to examine if there were differences across the device conditions based on the eight individual questions contained on the CES. There was one-within group factor "*Device Condition*" with three levels [post-Device A, post-Device B, post-Device C]. The individual questions on the CES served as the eight dependent variables [Q1CES, Q2CES, Q3CES, Q4CES, Q5CES, Q6CES, Q7CES, Q8CES].

Results of the one-factor RM MANOVA based on the eight CES questions revealed that the multivariate main effect of "*Device Condition*" approached significance, $F(16, 38)=1.910$, $p=0.051$, $\eta^2_{partial}=0.446$. Given the close to significant value of this multivariate statistic, the univariate main effects were examined. However, we chose to analyze the univariate statistics without employing the Bonferroni-corrected *p* value of .00625 (.05/8). It should be noted that this Bonferroni correction would have produced low critical *p* values, and this may raise concerns about the risk of producing a Type 2 error (i.e., failing to find a significant difference in devices when a difference exists; false negative). This potential concern about the risk of Type 2 errors with the use of Bonferroni corrections in a small-sample studies have been previously discussed (Andretta et al., 2015; Nakagawa, 2004). To address this potential concern, the uncorrected *p* values for each of the following univariate results and post hoc comparisons related to each of the outcome measures will be provided below.

A significant univariate main effect was found for CES question 4: "*Conversing with a stranger over the telephone" F*(2, 26)=3.54, *p*=0.043, $\eta^2_{partial}$ =0.214. This result suggests that participants with hypophonia rated communicative effectiveness related to speaking with a stranger over the phone significantly different across the three devices. A significant univariate main effect was also found for CES question 8: "*Having a conversation with someone at a distance (across a room)*" *F*(2, 26)=5.302, *p*=0.012, $\eta^2_{partial}$ =0.290. This result suggests that participants with hypophonia rated communicative effectiveness related to conversing over a distance significantly different across the three devices. Univariate main effects did not reach significance for CES questions 1, 2, 3, 5, 6 and 7. The univariate statistics for each CES question are presented in Table 15. Table 16 reports the descriptive statistics of the individual CES questions.

Table 15

Individual CES items based on device

CES Items	***F*(2, 26)**	***P***	$\eta^2_{partial}$
Q1	.047	.995	.004
Q2	.157	.856	.012
Q3	2.38	.112	.155
Q4	3.54	.043	.214
Q5	2.96	.069	.186
Q6	2.76	.079	.177
Q7	.351	.707	.026
Q8	5.30	.012	.290

Table 16

Descriptive statistics for CES items Q1-Q8 based on device

Q1-Q4 CES	**N**	**Mean (SD)**	**Q5-Q8 CES**	**N**	**Mean (SD)**
Q1 Device A	14	3.14 (.66)	Q5 Device A	14	2.43 (.85)
Q1 Device B	14	3.14 (.77)	Q5 Device B	14	2.93 (.61)
Q1 Device C	14	3.21 (.69)	Q5 Device C	14	2.79 (.57)
Q2 Device A	14	2.79 (.69)	Q6 Device A	14	2.14 (.94)
Q2 Device B	14	2.86 (.86)	Q6 Device B	14	2.64 (.92)
Q2 Device C	14	2.71 (.91)	Q6 Device C	14	2.71 (.61)
Q3 Device A	14	2.64 (.74)	Q7 Device A	14	2.86 (.66)
Q3 Device B	14	2.86 (.53)	Q7 Device B	14	2.79 (.80)
Q3 Device C	14	2.21 (1.05)	Q7 Device C	14	3.00 (.78)
Q4 Device A	14	2.36 (.63)	Q8 Device A	14	2.71 (.82)
Q4 Device B	14	2.57 (.51)	Q8 Device B	14	3.36 (.84)
Q4 Device C	14	1.93 (.99)	Q8 Device C	14	3.29 (.46)

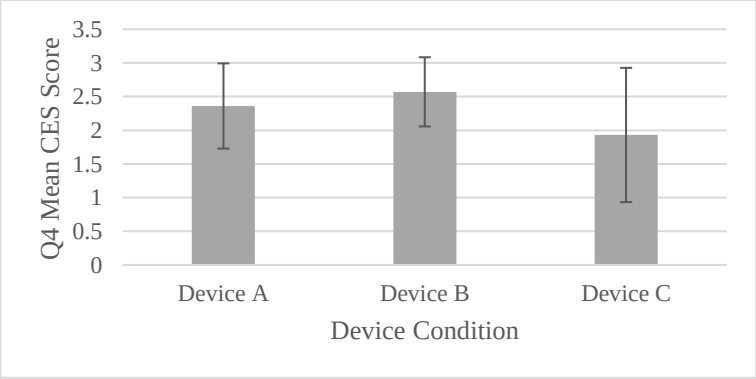
Note. N=14; Three HP participants were not included in this analysis due to incompletion of the CES for at least one of the devices

Post hoc comparisons. Post hoc comparisons using the LSD method, were completed for individual CES question with significant univariate main effects (CES questions 4, 8) to explore potential differences based on specific devices. The post hoc analyses focused on the following three comparisons: 1. post-Device A versus post-Device B, 2. post-Device B versus post-Device C, and 3. post-Device A versus post-Device C.

CES Q4: Conversing with a stranger over the telephone. The post hoc comparisons based on this question indicated that the mean score for CES Q4 for the 'post-device B' (M=2.57, SD=0.51) was significantly different (p=0.022), than 'post-device C' (M=1.93, SD=0.99). This result suggests that participants with hypophonia reported more effective communication when conversing with a stranger on the telephone when using Device B (M=2.57, SD=0.51) as compared to Device C (M=1.93, SD=0.99). The post hoc comparisons for 'post-device A' (M=2.36, SD=0.63) was not significantly different (p=0.336) than 'post-device B' (M=2.57, SD=0.51). As well, 'post-device A' (M=2.36, SD=0.63) was not significantly different (p=0.139) than 'post-device C' (M=1.93, SD=0.99). Please see Figure 13 for a graphic representation of these results.

Figure 13

Q4CES mean scores for each device
Standard deviations are expressed by Error Bars

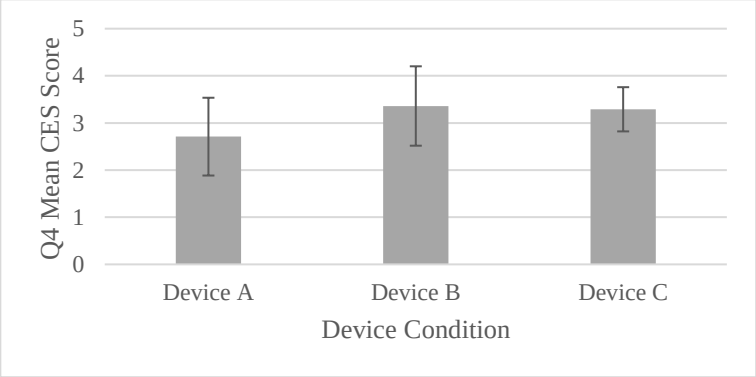


CES Q8: Having a conversation with someone at a distance (across a room). The post hoc comparisons based on this question indicated that the mean score for CES Q8 for 'post-device A' (M=2.71, SD=0.82) was significantly different (p=0.007) than 'post-

device B' (*M*=3.36, *SD*=0.84). In addition, the mean score for CES Q8 'post-device A' (*M*=2.71, *SD*=0.82) was significantly different (*p*=0.014) than 'post-device C' (*M*=3.29, *SD*=0.842). This result suggests that Device B and Device C produced differences with respect to engaging in conversation with another individual at a distance, indicating that the participants rated themselves as more effective when trialing Device B and Device C than when trialing Device A. There was no significance detected (*p*=0.775) when comparing Device B and Device C for this CES item. Please see Figure 14 for a graphic representation of these results.

Figure 14

Q8CES mean scores for each device
Standard deviations are expressed by Error Bars



The detailed results of this repeated measures MANOVA analysis and the corresponding post-hoc comparisons are presented in Appendix P.

3.4.2 Objective 2B: Voice Activity and Participation.

Three one-factor repeated measure ANOVAs and one repeated measured MANOVA were conducted to evaluate differences in voice activity and participation across device conditions.

Repeated Measures ANOVAs. The first RM ANOVA was based on *Total VAPP* scores, the second RM ANOVA was based on the *VAPP ALS (Activity Limitation Score)*, and the third RM ANOVA was based on the *VAPP PRS (Participation Restriction Score)*. For the first analysis, the dependent variable was "*Total VAPP*", for the second

analysis, the dependent variable was "*VAPP ALS,*" and for the third analysis, the dependent variable was "*VAPP PRS."* For all three analyses, there was one within-group factor, "*Device Condition*" with three levels [post-Device A, post-Device B, and post Device-C].

Total VAPP score. The first analysis which was based on the *Total VAPP* score did not reveal a significant difference across 'device condition', $F(2, 30)=0.397$, $p=0.676$. This result suggests *Total VAPP* scores are not rated significantly different by participants with hypophonia across the three device conditions. Table 17 presents the descriptive statistics for the one-factor RM ANOVA analysis based on *Total VAPP* scores.

Table 17

Descriptive statistics for Total VAPP scores based on device

Device Condition	N	Mean (SD)
Device A	16	81.43 (41.57)
Device B	16	86.04 (51.79)
Device C	16	77.89 (28.32)

Note. N=16; One HP participant was not included in this analysis due to incompletion of the VAPP

VAPP ALS. The second analysis which was based on the *VAPP ALS* did not reveal a significant difference across '*Device condition', F*(2, 30)=0.262, *p*=0.771. This result suggests *ALS* scores are not rated significantly different by participants with hypophonia across the three device conditions. Table 18 presents the descriptive statistics for the one-factor RM ANOVA analysis based on the *VAPP ALS*.

Table 18

Descriptive statistics for ALS VAPP scores based on device

Device Condition	N	Mean (SD)
Device A	16	6.23 (3.87)
Device B	16	6.91 (5.01)
Device C	16	6.42 (2.94)

Note. N=16; One HP participant was not included in this analysis due to incompletion of the VAPP

VAPP PRS. The third analysis which was based on the *VAPP PRS* score did not reveal a significant difference across *'Device condition', F*(2, 30)=1.910, *p*=0.166. This result suggests participation restriction scores are not rated significantly different by

participants with hypophonia across the three device conditions. Table 19 presents the descriptive statistics for the one-factor RM ANOVA analysis based on the *VAPP PRS.*

Table 19

Descriptive statistics for VAPP PRS based on device

Device Condition	N	Mean (SD)
Device A	16	5.34 (4.15)
Device B	16	7.22 (5.93)
Device C	16	5.40 (3.08)

Note. N=16; One HP participant was not included in this analysis due to incompletion of the VAPP

RM MANOVA. A repeated measures one-factor MANOVA was conducted to examine potential differences across the three device conditions based on the four subscale categories on the VAPP. There was one-within group factor "*Device Condition*" with three levels [post-Device A, post-Device B, post-Device C]. The VAPP subscale categories (Category 1: *Self- perceived severity of voice problem*; Category 3: *Effect on daily communication*; Category 4: *Effect on social communication*; Category 5: *Effect on emotion*) served as the four dependent variables labeled [C1VAPP, C3VAPP, C4VAPP, C5VAPP]. Although there are a total of five subscale categories on the VAPP, Category 2: *Effect on job*, was omitted because most HP participants were not employed because they were retired. Table 20 presents the descriptive statistics obtained for each device condition based on the RM ANOVA analysis.

Table 20

Descriptive statistic for VAPP subscale categories C1, C3, C4, C5 based on device

VAPP subscale categories based on Device	N	Mean (SD)
C1 Device A	16	3.20 (1.99)
C1 Device B	16	3.82 (2.57)
C1 Device C	16	3.60 (2.08)
C3 Device A	16	38.79 (20.33)
C3 Device B	16	40.43 (26.59)
C3 Device C	16	39.01 (16.64)
C4 Device A	16	12.59 (8.62)
C4 Device B	16	12.81 (9.48)
C4 Device C	16	11.82 (6.70)
C5 Device A	16	26.83 (17.71)
C5 Device B	16	28.96 (18.43)
C5 Device C	16	23.45 (11.94)

Note. N=16; One HP participant was not included in this analysis due to incompletion of the VAPP

Results of the RM MANOVA with the four VAPP dependent variables did not reveal a significant multivariate effect for "*Device Condition*" $F(8, 54)=0.480$, $p=0.865$; $\eta^2_{partial}=0.066$. This result indicates there was not a significant device effect detected for voice activity and participation scores across any of the four VAPP subscale categories. Table 21 presents the univariate results of the RM MANOVA of this objective. The detailed results of this repeated measures MANOVA analysis are presented in Appendix Q.

Table 21

Effect of Device Condition based on VAPP subscale items C1, C3, C4, C5

VAPP Categories	***F*(2, 30)**	***p***	$\eta^2_{partial}$
C1	.424	.659	.027
C3	.056	.945	.004
C4	.151	.861	.010
C5	1.072	.355	.067

3.4.3. Objective 2C: Psychosocial Impact of Assistive Devices.

Three separate one-factor repeated measures ANOVAs were conducted to evaluate differences in ratings of psychosocial impact across device conditions.

Repeated Measures ANOVAs. The first RM ANOVA was based on the *PIADS Competence* subscale score, the second RM ANOVA was based on the *PIADS Adaptability* subscale score, and the third RM ANOVA was based on the *PIADS Self-Esteem* subscale score. For the first analysis, the dependent variable was the "*PIADS Competence*," subscale score, for the second analysis, the dependent variable was the "*PIADS Adaptability*," subscale score, and for the third analysis, the dependent variable was the "*PIADS Self-Esteem"* subscale score. For all three analyses, there was one within-group factor, "*Device Condition*" with three levels [post-Device A, post-Device B, and post Device-C]. Based on this objective, comparisons examined whether self-rated '*Competence*' subscale scores of the PIADS differed across the three device conditions; whether self-rated '*Adaptability*' subscale scores differed across the three device conditions; and finally, whether the '*Self-esteem'* subscale scores differed across the three device conditions.

PIADS Competence. The first analysis which was based on the *PIADS Competence* subscale score did not reach significance across "*Device Condition*" $F(2, 30)=0.932$, $p=0.405$. Table 22 presents the descriptive statistics for the one-factor RM ANOVA analysis based on *PIADS Competence* subscale scores. This result suggests that participants with hypophonia did not rate their competence using an assistive device as significantly different across the three amplification devices trialed.

Table 22

Descriptive statistics for PIADS Competence subscale score based on device

Device Condition	N	Mean (SD)
Device A	16	.60 (.54)
Device B	16	.62 (.56)
Device C	16	.86 (.87)

Note. N=16; One HP participant was not included in this analysis due to incompletion of the PIADS

PIADS Adaptability. The second analysis which was based on the *PIADS Adaptability* subscale scores did not reach significance across "*Device Condition*" $F(2, 30)= 0.822$, $p=0.449$. Table 23 presents the descriptive statistics for the one-factor RM ANOVA analysis based on the *PIADS Adaptability* subscale scores. This result suggests that participants with hypophonia did not rate adaptability using an assistive device as significantly different across the three amplification devices trialed.

Table 23

Descriptive statistics for PIADS Adaptability subscale score based on device

Device Condition	N	Mean (SD)
Device A	16	.74 (.73)
Device B	16	.67 (.76)
Device C	16	.90 (.68)

Note. N=16; One HP participant was not included in this analysis due to incompletion of the PIADS

PIADS Self-Esteem. The third analysis which was based on the *PIADS Self-Esteem* subscore did not reveal significance in self-esteem subscale scores across "*Device Condition*" $F(2, 30)=0.539$, $p=0.589$. Table 24 presents the descriptive statistics for the one-factor RM ANOVA analysis based on the *PIADS Self-Esteem* subscale scores. This result suggests that participants with hypophonia did not rate self-esteem significantly different across the three amplification devices trialed.

Table 24

Descriptive statistics for PIADS Self-esteem subscale score based on device

Device Condition	N	Mean (SD)
Device A	16	.47 (.81)
Device B	16	.48 (.66)
Device C	16	.66 (.80)

Note. N=16; One HP participant was not included in this analysis due to incompletion of the PIADS

Overall, these results indicate that the psychosocial impact of using an amplification device based on the parameters of self-rated competence, adaptability, and self-esteem were not rated significantly different by our participants with hypophonia across the three assistive devices trialed.

3.5 Objective 3: To determine if ratings of communicative participation differ for individuals with hypophonia versus their primary communication partners across device conditions.

The purpose of this objective was to evaluate and determine if ratings of communicative participation differ between individuals with hypophonia and their primary communication partners across the three device conditions. Specifically, the aim of this objective was to determine if there were any differences in self-rated communicative effectiveness, voice activity and participation, and the psychosocial impact of device use between the participants with hypophonia and their primary communication partners before device use and after device trials.

3.5.1 Objective 3A: Communicative Effectiveness.

Two, two-factor RM ANOVAs and a two-factor RM MANOVA were conducted to evaluate communicative effectiveness between participant groups across device conditions. More specifically, this sub-objective sought to determine whether total and mean communicative effectiveness scores differed between participant groups across device conditions.

Two-factor RM ANOVAs. The first RM ANOVA was based on the *Total CES* score, and the second RM ANOVA was based on the *Mean CES* score. For the first analysis, the dependent variable was "*Total CES*" and for the second analysis, the dependent variable was "*Mean CES*." For both analyses, there was one within-group independent variable "*Device condition*" with four levels [pre-Device, post-Device A, post-Device B, post-Device C] and one between-group independent variable "*Group*" with two levels [HP participants (Group 1), PCP participants (Group 2)].

Total CES. Table 25 presents the descriptive statistics for the two-factor RM ANOVA and the *Total CES* scores are represented graphically in Figure 15. The first analysis which was based on the *Total CES* score revealed a statistically significant difference (p=0.000) of *Total CES scores* for the within-subjects factor "*Device condition"*, $F(3, 96)=11.74$. This result suggests that overall, the participants with hypophonia and their communication partners rated communication effectiveness (of the participants with hypophonia) as lower in the pre-device condition (M=17.76, SD=4.92) and rated communication as more effective during the device trial conditions (Device A: M=21.55, SD=4.55; Device B: M=22.75, SD=4.53; Device C: M=22.23, SD=4.51) based on the *Total CES* score. The between-subjects factor "*Group"* did not reach significance, $F(1, 32)=0.371$, p=0.577. This result indicates that the ratings provided by the participants with hypophonia (Pre-Device: M=17.76, SD=5.90; Device A: M=21.17, SD=3.67; Device B: M=22.17, SD=4.57; Device C: M=21.52, SD=4.28) were not significantly different from the ratings made by their primary communication partners for the same device conditions (Pre-Device: M=16.82, SD=3.84; Device A: M=21.94, SD=5.37; Device B: M=23.35, SD=4.56; Device C: M=22.94, SD=4.76). In addition, the "*Device Condition" x "Group"* interaction was not significant, $F(3, 96)=0.553$, p=0.661. This result is illustrated in Figure 15 with associated means and standard error scores. This non-significant interaction indicates that each group gave a similar pattern of CES ratings across the different device types and conditions.

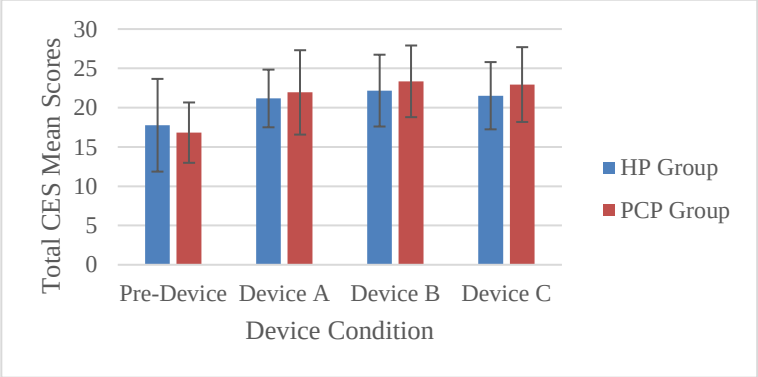
Table 25

Descriptive statistics for Total CES obtained from HP and PCP participants in each device condition

Device Condition	Group	N	Mean (SD)
Pre-Device	HP	17	17.76 (5.90)
	PCP	17	16.82 (3.84)
	Total	34	17.29 (4.92)
Device A	HP	17	21.17 (3.67)
	PCP	17	21.94 (5.37)
	Total	34	21.55 (4.55)
Device B	HP	17	22.17 (4.57)
	PCP	17	23.35 (4.56)
	Total	34	22.76 (4.53)
Device C	HP	17	21.52 (4.28)
	PCP	17	22.94 (4.76)
	Total	34	22.23 (4.51)

Figure 15

Total CES mean scores for the HP and PCP groups based on device condition Standard deviations are expressed by Error Bars



Mean CES. The second analysis which was based on *Mean CES* scores revealed a statistically significant difference (p=0.000) for *Mean CES scores* for the within-subjects factor "*Device condition"*, $F(3, 96)=11.74$. This result suggests participants with hypophonia rated themselves as less effective communicators (M=2.22, SD=0.73) in the pre-device condition and more effective communicators during the device trial conditions (Device A: M=2.64, SD=0.45; Device B: M=2.77, SD=0.57; Device C: M=2.69, SD=0.53) based on the Mean CES score. The between-subjects factor "*Group"* did not reach significance, $F(1, 32)=0.371$, p=0.547. This result indicates that the ratings made

by the participants with hypophonia (Pre-Device: *M*=2.22, *SD*=0.73, Device A: *M*=2.64, *SD*=0.45; Device B: *M*=2.77, *SD*=0.57; Device C: *M*=2.69, *SD*=0.53) were not significantly different from the ratings made by their primary communication partners during the same device conditions (Pre-Device: *M*=2.10, *SD*=0.48, Device A: *M*=2.73, *SD*=0.67; Device B: *M*=2.91, *SD*=0.57; Device C: *M*=2.86, *SD*=0.56). In addition, the "*Device Condition" x "Group"* interaction was not significant, *F*(3, 96)=0.553, *p*=0.661. This result indicates that each group gave a similar pattern of CES ratings based on the *Mean CES* score across the different device types and conditions. This result is illustrated in Figure 16 with associated means and standard error scores. Table 26 presents the descriptive statistics for the RM ANOVA and the *Mean CES* scores.

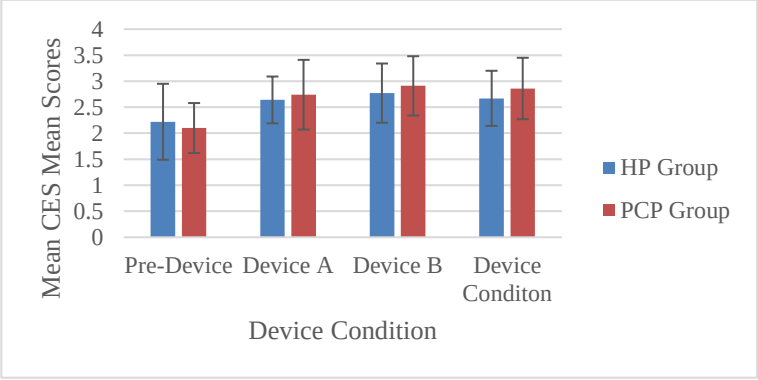
Table 26

Descriptive statistics for Mean CES obtained from HP and PCP participants in each device condition

Device Condition	Group	N	Mean (SD)
Pre-Device	HP	17	2.22 (.73)
	PCP	17	2.10 (.48)
	Total	34	2.16 (.61)
Device A	HP	17	2.64 (.45)
	PCP	17	2.74 (.67)
	Total	34	2.69 (.56)
Device B	HP	17	2.77 (.57)
	PCP	17	2.91 (.57)
	Total	34	2.84 (.56)
Device C	HP	17	2.69 (.53)
	PCP	17	2.86 (.59)
	Total	34	2.77 (.56)

Figure 16

Mean CES mean scores for the HP and PCP groups based on device condition Standard deviations are expressed by Error Bars



Two-factor RM MANOVA. A two-factor RM MANOVA was conducted to examine if there were differences between groups across device conditions. There was one within-group independent variable "*Device Condition*" with four levels [Pre-Device, Device A, Device B, Device C] and one between-group independent variable "*Group*" with two levels [HP participants (Group 1), PCP participants (Group 2)]. The individual questions on the CES served as the eight dependent variables [Q1CES, Q2CES, Q3CES, Q4CES, Q5CES, Q6CES, Q7CES, Q8CES]. The detailed results of this two-factor repeated measures MANOVA analysis are presented in Appendix R.

Results of the two-factor RM MANOVA reached significance for the within-subjects factor "*Device condition"*, $F(24, 223)=5.512$, $p=0.000$, $\eta^2_{partial}= 0.346$. The between-subjects factor "*Group"*, $F(8, 21)=0.910$, $p=0.527$, $\eta^2_{partial}= 0.257$ did not reach significance. The "*Device condition" x "Group"* interaction was not significant, $F(24, 223)=1.290$, $p=0.172$. $\eta^2_{partial}=0.118$. The descriptive statistics are presented in Table 27.

Table 27

Descriptive statistics for CES Q1-Q8 items obtained for HP and PCP participants in each device condition

CES Q1-Q4 based on device	Group	N	Mean (SD)	CES Q5-Q8 based on device	Group	N	Mean (SD)
Q1 Pre-Device	HP	14	2.92 (.73)	Q5 Pre-Device	HP	14	1.92 (.91)
	PCP	16	2.62 (.88)		PCP	16	1.56 (.62)
	Total	30	2.76 (.81)		Total	30	1.73 (.78)
Q1 Device A	HP	14	3.14 (.66)	Q5 Device A	HP	14	2.42 (.85)
	PCP	16	2.93 (.77)		PCP	16	2.81 (.75)
	Total	30	3.03 (.71)		Total	30	2.63 (.80)
Q1 Device B	HP	14	3.14 (.77)	Q5 Device B	HP	14	2.92 (.61)
	PCP	16	3.43 (.62)		PCP	16	2.81 (.75)
	Total	30	3.30 (.70)		Total	30	2.86 (.68)
Q1 Device C	HP	14	3.21 (.69)	Q5 Device C	HP	14	2.78 (.57)
	PCP	16	3.43 (.72)		PCP	16	2.43 (1.09)
	Total	30	3.33 (.71)		Total	30	2.60 (.89)
Q2 Pre-Device	HP	14	2.42 (.93)	Q6 Pre-Device	HP	14	2.00 (.87)
	PCP	16	2.43 (.81)		PCP	16	1.93 (.68)
	Total	30	2.43 (.85)		Total	30	1.96 (.76)
Q2 Device A	HP	14	2.78 (.69)	Q6 Device A	HP	14	2.14 (.94)
	PCP	16	2.81 (.75)		PCP	16	2.43 (.81)
	Total	30	2.80 (.71)		Total	30	2.30 (.87)
Q2 Device B	HP	14	2.85 (.86)	Q6 Device B	HP	14	2.64 (.92)
	PCP	16	3.18 (.75)		PCP	16	2.62 (.71)
	Total	30	3.03 (.80)		Total	30	2.63 (.80)

Q2 Device C	HP	14	2.71 (.91)	Q6 Device C	HP	14	2.71 (.61)
	PCP	16	3.00 (.96)		PCP	16	2.62 (.88)
	Total	30	2.86 (.93)		Total	30	2.66 (.75)
Q3 Pre-Device	HP	14	2.57 (.93)	Q7 Pre-Device	HP	14	2.21 (.97)
	PCP	16	2.37 (.71)		PCP	16	2.37 (.88)
	Total	30	2.46 (.81)		Total	30	2.30 (.91)
Q3 Device A	HP	14	2.64 (.74)	Q7 Device A	HP	14	2.85 (.66)
	PCP	16	2.56 (1.03)		PCP	16	3.00 (1.03)
	Total	30	2.60 (.89)		Total	30	2.93 (.86)
Q3 Device B	HP	14	2.85 (.53)	Q7 Device B	HP	14	2.78 (.80)
	PCP	16	2.81 (.75)		PCP	16	2.81 (.65)
	Total	30	2.83 (.64)		Total	30	2.80 (.71)
Q3 Device C	HP	14	2.21 (1.05)	Q7 Device C	HP	14	3.00 (.78)
	PCP	16	2.43 (1.09)		PCP	16	3.31 (.70)
	Total	30	2.33 (1.06)		Total	30	3.16 (.74)
Q4 Pre-Device	HP	14	2.28 (1.13)	Q8 Pre-Device	HP	14	2.07 (.91)
	PCP	16	1.75 (.68)		PCP	16	1.75 (.68)
	Total	30	2.00 (.94)		Total	30	1.90 (.80)
Q4 Device A	HP	14	2.35 (.63)	Q8 Device A	HP	14	2.71 (.82)
	PCP	16	2.37 (1.02)		PCP	16	3.31 (.70)
	Total	30	2.36 (.85)		Total	30	3.03 (.80)
Q4 Device B	HP	14	2.57 (.51)	Q8 Device B	HP	14	3.35 (.84)
	PCP	16	2.68 (.79)		PCP	16	3.5 (.51)
	Total	30	2.63 (.66)		Total	30	3.43 (.67)
Q4 Device C	HP	14	1.92 (.99)	Q8 Device C	HP	14	3.28 (.46)
	PCP	16	2.12 (1.20)		PCP	16	3.50 (.63)
	Total	30	2.03 (1.09)		Total	30	3.40 (.56)

**Note: N=14; Three HP participants were not included in this analysis due to incompletion of the CES for at least one of the devices, N=17; One PCP participant was not included in this analysis due to incompletion of the CES for one of the device trials*

***Device Condition*.** Based on the significant multivariate effect for the within-subjects factor "*Device condition", F*(24, 223)=5.512, *p*=0.000, $\eta^2_{partial}$= 0.346, the univariate effects were analyzed for each of the eight CES questions. Significant univariate main effects were found for CES question 1: "*Having a conversation with a friend or family member at home*", *F*(3, 84)=3.191, *p*=0.024, $\eta^2_{partial}$=0.105; CES question 2: "*Participating in conversations with strangers in a quiet place*", *F*(3, 84)=3.191, *p*=0.038, $\eta^2_{partial}$=0.102; CES question 4: "*Conversing with a stranger over the telephone*", *F*(3, 84)=4.259, *p*=0.008, $\eta^2_{partial}$=0.132; CES question 5: "*Being a part of a conversation in a noisy environment (social gathering)*", *F*(3, 84)=13.16, *p*=0.000, $\eta^2_{partial}$=0.320; CES question 6: "*Speaking to a friend when you are emotionally upset or you are angry*", *F*(3, 84)=5.868, *p*=0.001, $\eta^2_{partial}$=0.173; CES question 7: "*Having a conversation while travelling in a car*", *F*(3, 84)=6.586, *p*=0.000, $\eta^2_{partial}$=0.190; and CES question 8: *"Having a conversation with someone at a distance (across a room)*",

$F(3, 84)=34.372$, $p=0.000$, $\eta^2_{partial}=0.551$. These significant univariate effects can be interpreted by acknowledging that this device condition effect is most likely related to pre device versus post device conditions for both the HP and PCP groups. This device condition result is similar to the reported device conditions effect of the HP group analysis in Objective 1. The univariate statistics for the within-subjects factor "*Device condition*" are presented in Table 28 for each of the CES questions.

Table 28

Individual CES items based on device conditions for HP and PCP participants

CES items	$F(3, 84)$	p	$\eta^2_{partial}$
Q1	3.191	.024	.105
Q2	3.191	.028	.102
Q3	2.016	.118	.067
Q4	4.259	.008	.132
Q5	13.166	.000	.320
Q6	5.868	.001	.173
Q7	6.586	.000	.190
Q8	34.372	.000	.551

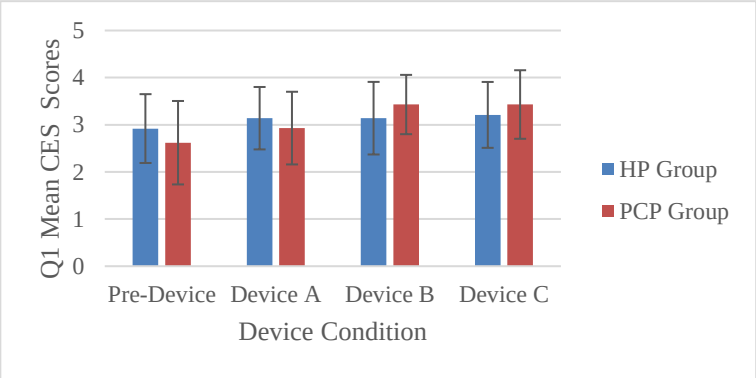
Post hoc comparisons. Post hoc comparisons using the LSD method, were completed for the CES questions with significant *Device condition* univariate main effects (CES questions:1, 2, 4, 5, 6, 7, 8) to explore and examine the differences based on pre-post device comparisons. The post hoc analyses focused on the three pre device versus post device comparisons (Pre versus Post device A, Pre versus Post device B, and Pre versus Post device C) across groups (HP participants versus PCP participants).

CES Q1: Having a conversation with a family member or friends at home. The post hoc comparisons related to Q1CES, indicated that the total Q1CES score was significant ($p=0.024$) between the 'pre-device' condition ($M=2.76$, $SD=0.81$) versus 'post-device B' condition ($M=3.30$, $SD=0.70$). Q1CES score showed significance ($p=0.026$) between the 'pre-device' condition ($M=2.76$, $SD=0.81$) versus 'post-device C' condition ($M=3.33$, $SD=0.71$). This result suggests Devices B and C were rated as the more effective amplification devices, in comparison to the pre-device trial, when an individual is conversing with a family member or friends in a home setting. Figure 17 illustrates the relationship among these device conditions between participant groups for this CES item. It is important to note, the relationship between groups for each device

condition for this CES variable, did not reach statistical significance $F(3, 84)=1.146$, $p=0.335$.

Figure 17

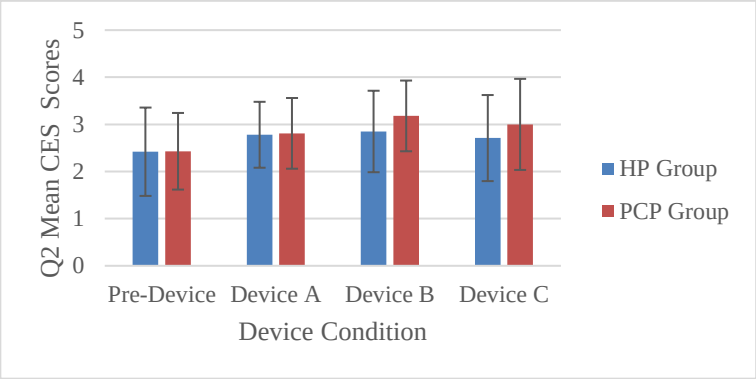
Q1CES mean scores for the HP and PCP groups based on device condition Standard deviations are expressed by Error Bars



CES Q2: Participating in conversations with strangers in a quiet place. The post hoc comparison related to Q2CES, indicated that the total Q2CES score was significant ($p=0.009$) between the 'pre-device' condition ($M=2.43$, $SD=0.85$) versus the 'post-device B' condition ($M=3.03$, $SD=0.81$). There was no significance reached between the 'pre-device' condition versus the 'post-device A' condition ($M=2.80$, $SD=0.71$; $p=0.067$) or the 'post-device C' condition ($M=2.86$, $SD=0.93$; $p=0.109$). This result suggests Device B was rated as a more effective amplification device, in comparison to the pre-device trial, when an individual is participating in conversation with strangers in a quiet environment. Figure 18 illustrates the relationship among these device conditions between participant groups for this CES item. It is important to note, the relationship between groups for each device condition for this CES variable, did not reach statistical significance $F(3, 84)=0.0367$, $p=0.777$.

Figure 18

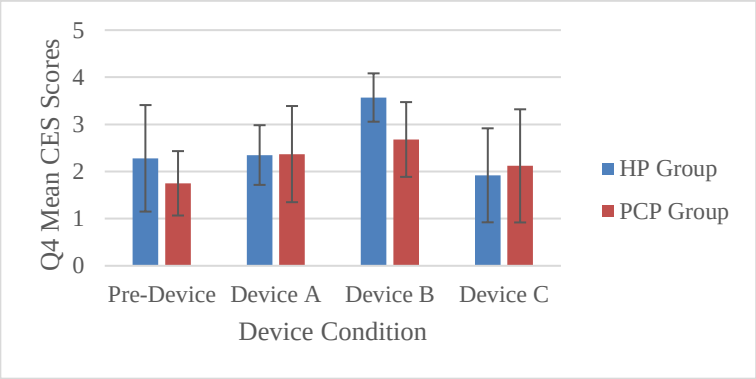
Q2CES mean scores for the HP and PCP groups based on device condition Standard deviations are expressed by Error Bars



CES Q4: Conversing with strangers over the telephone. The post hoc comparison related to Q4CES, indicated that the total Q4CES was significant (p=0.004) between the 'pre-device' condition (M=2.00, SD=0.94) versus the 'post-device B' condition (M=2.63, SD=0.66). There was no significance reached between the 'pre-device' condition versus the 'post-device A' condition (M=2.36, SD=0.85; p=0.176) or the 'post-device C' condition (M=2.03, SD=1.09; p=0.969). This result suggests Device B was rated as a more effective amplification device, in comparison to the pre-device trial, when an individual is conversing with strangers over the telephone. Figure 19 illustrates the relationship among these device conditions between participant groups for this CES item. It is important to note, the relationship between groups for each device condition for this CES variable, did not reach statistical significance $F(3, 84)=1.343$, p=0.266.

Figure 19

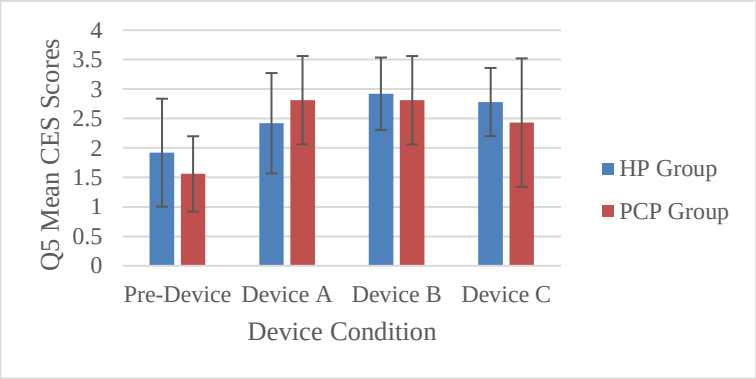
Q4CES mean scores for the HP and PCP groups based on device condition Standard deviations are expressed by Error Bars



CES Q5: Being a part of a conversation in a noisy environment (social gathering). The post hoc comparisons related to Q5CES, indicated that the total Q5CES was significant across all amplification devices. Significance was reached (p=0.000) for the 'pre-device' condition (M=1.73, SD=0.78) versus 'post-device A' condition (M=2.63, SD=0.80). Significance was also reached (p=0.000) for the 'pre-device' condition versus the 'post-device B' condition (M=2.86, SD=0.68) Finally, significance was reached for the 'pre-device' condition (p=0.001) versus the 'post-device C' condition (M=2.60, SD=0.89). These results suggest all three amplification devices were rated as more effective, in comparison to the pre-device trial, when in an individual is conversing in a noisy environment, such as a social gathering. Figure 20 illustrates the relationship among these device conditions between participant groups for this CES item. It is important to note, the relationship between groups for each device condition for this CES variable, did not reach statistical significance $F(3, 84)=1.657$, p=0.183.

Figure 20

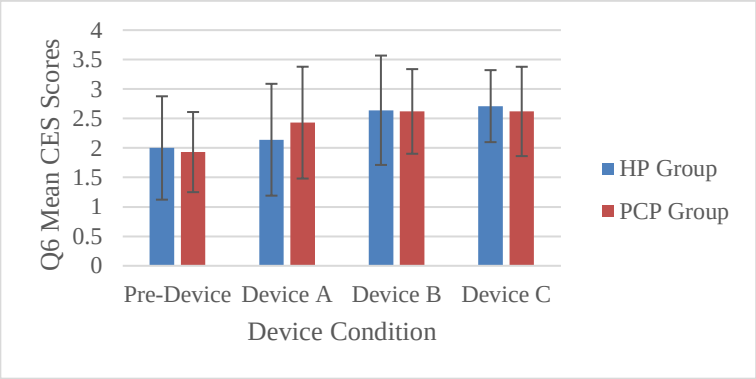
Q5CES mean scores for the HP and PCP groups based on device condition Standard deviations are expressed by Error Bars



CES Q6: Speaking to a friend when you are emotionally upset or you are angry. The post hoc comparisons related to Q6CES, indicated that the total Q6CES score was significant (p=0.006) between the 'pre-device' condition (M=1.96, SD=0.76) versus the 'post-device B' condition (M=2.63, SD=0.80). Significance was also reached (p=0.001) when comparing the 'pre-device' condition versus the 'post-device C' condition (M=2.66, SD=0.75). There was no significance reached between the 'pre-device' condition versus the 'post-device A' condition (p=0.131). This result suggests Device A is not an effective amplification device, in comparison to the pre-device trial, when in an individual is speaking to a friend when they are angry or upset. Devices B and C are more effective for this self-rated communicative participation item measure. Figure 21 illustrates the relationship among these device conditions between participant groups for this CES item. It is important to note, the relationship between groups for each device condition for this CES variable, did not reach statistical significance $F(3, 84)=0.429$, p=0.733.

Figure 21

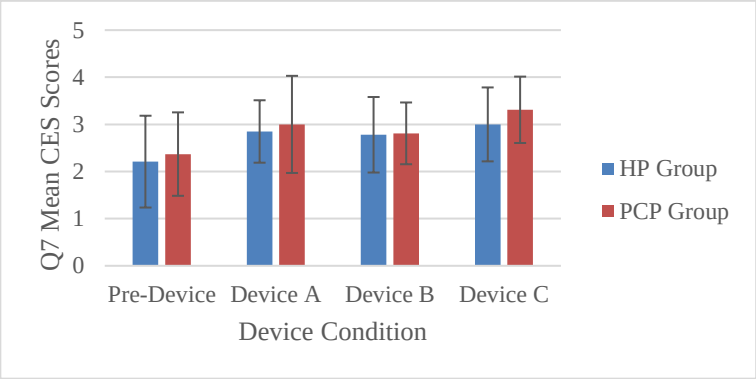
Q6CES mean scores for the HP and PCP groups based on device condition Standard deviations are expressed by Error Bars



*CES 7: Having a conversation while travelling in a car***.** The post hoc comparisons related to Q7 was statistically significant across all three amplification devices. Question 7 of the CES was significant (p=0.002) for the comparison of the 'pre-device' condition (M=2.30, SD=0.91) versus the 'post-device A' condition (M=2.93, SD=0.86). There was also significance reached (p=0.012) when comparing the 'pre-device' condition versus the 'post-device B' condition (M=2.80, SD=0.71). Finally, significance was reached (p=0.001) when comparing the 'pre-device' condition versus the 'post-device C' condition (M=3.16, SD=0.74). These results suggest all three amplification devices were rated as more effective, in comparison to the pre-device trial, when an individual is conversing while travelling in a vehicle. Figure 22 illustrates the relationship among these device conditions between participant groups for this CES item. It is important to note, the relationship between groups for each device condition for this CES variable, did not reach statistical significance $F(3, 84)=0.171$, p=0.916.

Figure 22

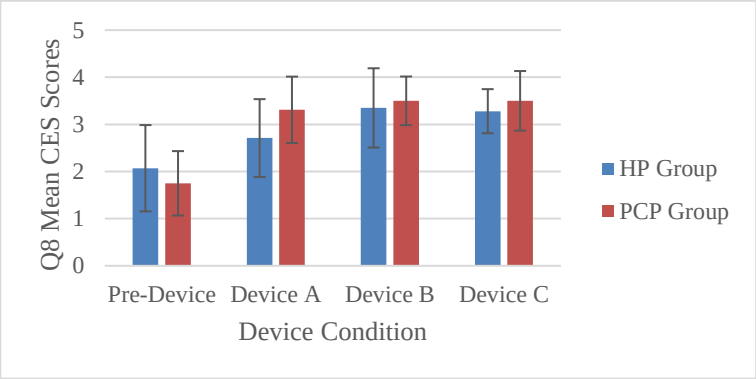
Q7CES mean scores for the HP and PCP groups based on device condition Standard deviations are expressed by Error Bars



CES Q8: Having a conversation with someone at a distance (across a room). The post hoc comparisons related Q8CES, was significant across all devices. Firstly, the total Q8CES score was significant (p=0.000) when comparing the 'pre-device' condition (M=1.90, SD=0.80) versus the 'post-device A' condition (M=3.03, SD=0.80). Secondly, significance was reached (p=0.000), when comparing the 'pre-device' condition versus the 'post-device B' condition (M=3.43, SD=0.67). Finally, significance was reached (p=0.000) when comparing the 'pre-device' condition versus the 'post-device C' condition (M=3.40, SD=0.56). This result suggests all three devices are more effective, in comparison to the pre-device trial, when in an individual is having a conversation with someone at a distance (such as when the individual is across a room). Figure 23 illustrates the relationship among these device conditions between participant groups for this CES item. It is important to note, the relationship between groups for each device condition for this CES variable, did not reach statistical significance $F(3, 84)=2.43$, p=0.071.

Figure 23

Q8CES mean scores for the HP and PCP groups based on device condition Standard deviations are expressed by Error Bars



Taken together, these results suggest that these specific CES questions may be capturing *pre-post* device effects based on ratings of communicative effectiveness. The interpretation of these results and the potential importance of these questions will be expanded upon further in the Discussion.

Group. From the univariate results of the two-factor RM MANOVA for between-subjects *Group* was examined further. As reported above, no significant multivariate effects were reached for the between-group factor "*Group*", $F(8, 21)=0.910$, $p=0.527$, $\eta^2_{partial}= 0.257$, so the comparison alpha was adjusted for each of the subsequent univariate analyses (i.e., $\alpha/8 = 0.00625$). Within the univariate effects, main effects did not reach significance for all CES items. These analyses are reported within Table 29. Descriptive statistics are presented above in Table 27. The non-significant group difference suggests that there was no difference in the CES ratings between participants with hypophonia and their primary communication partners.

Table 29

Univariate results for the between-group factor (HP versus PCP groups) for each of the 8 CES items

CES items	*F*(1, 28)	*p*	$\eta^2_{partial}$
Q1	.000	.985	.000
Q2	.726	.401	.025
Q3	.017	.896	.001
Q4	.054	.819	.002
Q5	.431	.517	.015
Q6	.029	.865	.001
Q7	.849	.365	.029
Q8	1.072	.309	.037

Device Condition x Group. As shown above, the "*Device Condition" x "Group"* interaction did not reach significance, $F(24, 223)=1.290$, $p=0.172$. $\eta^2_{partial}=0.118$. Table 30 reports the univariate results. As displayed in Table 30, CESQ8: *having a conversation with someone at a distance (across a room)*, approached significance, $p=0.071$. This finding will be discussed further in the next chapter. These non-significant interactions suggest that each group demonstrated a similar pattern of CES ratings across the different device types for each of the variables. Table 30 presents the associated *p*-values for this interaction.

Table 30

Univariate results for the between-group factor (HP versus PCP groups) for each of the 8 CES items in each device condition

CES items	*F*(3, 84)	*p*	$\eta^2_{partial}$
Q1	1.146	.335	.039
Q2	0.367	.777	.013
Q3	0.341	.796	.012
Q4	1.343	.266	.046
Q5	1.657	.183	.056
Q6	0.429	.733	.015
Q7	0.171	.916	.006
Q8	2.432	.071	.080

3.5.2 Objective 3B: Voice Activity and Participation.

Three, two-factor RM ANOVAs and a single two-way RM MANOVA were conducted to evaluate voice activity and participation between participant groups across device conditions.

Two-factor RM ANOVAs. The first two-factor RM ANOVA was based on *Total VAPP* scores, the second two-factor RM ANOVA was based on *VAPP ALS (Activity Limitation Scores)*, and the third on *VAPP PRS (Participation Restriction Scores).* For the first analysis, the dependent variable was "*Total VAPP*," the second analysis, the dependent variable was "*VAPP ALS,*" and the third analysis, the dependent variable was "*VAPP PRS."* For all three analyses, there was one within-group factor, "*Device Condition*" with four levels [pre-Device use, post-Device A, post-Device B, and post Device-C] and one between-group independent factor "*Group*" with two levels [HP participants (Group 1), PCP participants (Group 2)]. Based on this objective, the following comparisons were made: to determine whether total voice activity and participation scores differ between participant groups across device conditions and to determine whether self-rated activity limitation scores and participation restriction scores differ between participant groups across device conditions.

Total VAPP scores. The first analysis which was based on *Total VAPP* scores revealed a statistically significant result for within-subjects effect "*Device condition"* factor, $F(3, 93)=28.22$, $p=0.000$. This result suggests the *Total VAPP* scores combined for both participant groups are sensitive to pre-device use ($M=149.50$, $SD=46.74$) versus post-device use (Device A: $M=88.51$, $SD=46.95$; Device B: $M=87.36$, $SD=50.78$; Device C: $M=89.05$, $SD=40.63$). When examining between-subjects effect "G*roup"* condition factor, $F(1, 31)=0.776$, $p=0.385$ there were no significant values reached. This result indicates that the self-rated VAPP scores provided by the participants with hypophonia (Pre-Device: $M=145.80$, $SD=50.49$; Device A: $M=81.43$, $SD=41.57$; Device B: $M=86.04$, $SD=51.75$; Device C: $M=77.89$, $SD=28.32$) were not significantly different from the ratings made by their primary communication partners during the same device conditions (Pre-Device: $M=152.99$, $SD=44.19$; Device A: $M=95.18$, $SD=51.87$; Device B: $M=88.60$, $SD=51.40$; Device C: $M=99.55$, $SD=48.04$). In addition, the "*Device*

Condition" x "Group" interaction was not significant $F(3, 93)=0.517$, $p=0.671$, indicating there were no significant differences between the two groups for self-ratings of voice activity and participation during the device trial conditions. Table 31 presents the descriptive statistics and Figure 24 presents the interaction between groups for ratings of total voice activity and participation across devices.

Table 31

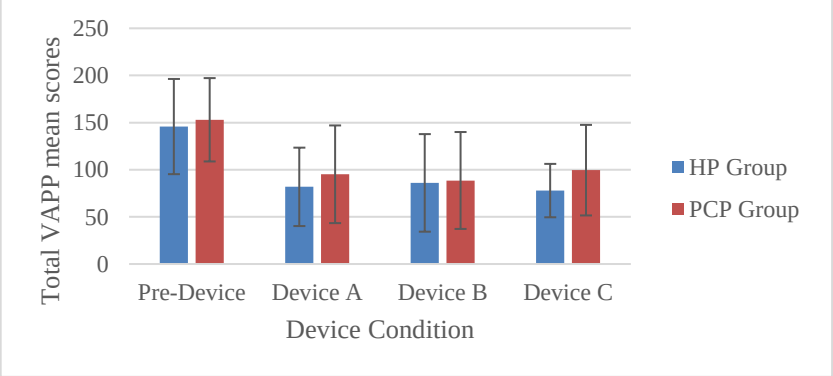
Descriptive statistics for Total VAPP scores obtained for the participants with hypophonia (HP) and their primary communication partners (PCP) across the device conditions

Device Condition	Group	N	Mean (SD)
Pre-Device	HP	16	145.80 (50.49)
	PCP	17	152.99 (44.19)
	Total	33	149.50 (46.74)
Device A	HP	16	81.43 (41.57)
	PCP	17	95.18 (51.87)
	Total	33	88.51 (46.95)
Device B	HP	16	86.04 (51.75)
	PCP	17	88.60 (51.40)
	Total	33	87.36 (50.78)
Device C	HP	16	77.89 (28.32)
	PCP	17	99.55 (48.04)
	Total	33	89.05 (40.63)

Note. N=16; One HP participant was not included in this analysis due to incompletion of the VAPP

Figure 24

Total VAPP mean scores between HP and PCP groups based on device condition Standard deviations are expressed by Error Bars



VAPP ALS scores. The second analysis which was based on *VAPP ALS* scores revealed a statistically significant result of the multivariate analysis for within-subjects

effect "*Device condition"* factor, $F(3, 93)=32.81$, $p=0.000$. This result suggests the activity limitation scores combined for both participant groups are sensitive to pre-device use ($M=14.75$, $SD=4.85$) versus post-device use (Device A: $M=7.45$, $SD=4.8$*;* Device B: $M=87.36$, $SD=50.78$; Device C: $M=89.05$, $SD=40.63$). When examining between-subjects effect "*Group"* condition factor, $F(1, 31)=1.641$, $p=0.210$ no significant differences were found. This result indicates that the ALS ratings provided by the participants with hypophonia (Pre-Device: $M=14.01$, $SD=5.16$; Device A: $M=6.23$, $SD=3.87$; Device B: $M=6.91$, $SD=5.01$; Device C: $M=6.42$, $SD=2.93$) were not significantly different from the ratings made by primary communication partners during the same device conditions (Pre-Device: $M=15.36$, $SD=4.59$; Device A: $M=8.61$, $SD=5.39$; Device B: $M=6.68$, $SD=4.77$; Device C: $M=8.96$, $SD=5.05$). In addition, the results of the *"Device condition" x "Group"* interaction was not significant $F(3, 93)=0.963$, $p=0.414$. This non-significant interaction indicates that each group gave a similar pattern of activity limitation ratings across the different device types. Table 32 presents the descriptive statistics for the *VAPP ALS* scores. Figure 25 presents the interaction between groups for ratings of pre-post activity limitation across devices.

Table 32

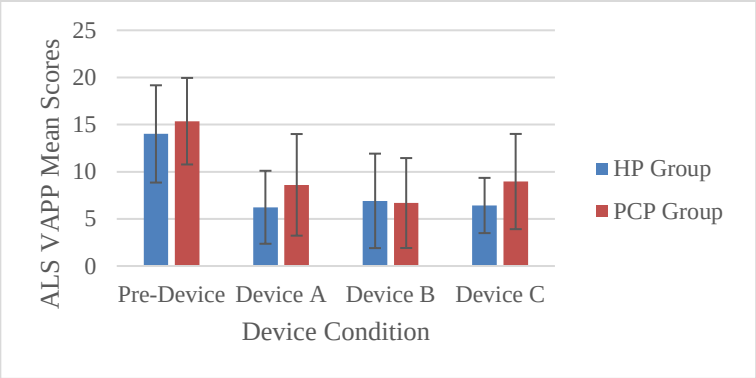
Descriptive statistics VAPP ALS mean scores obtained for the participants with hypophonia (HP) and their primary communication partners (PCP) across the device conditions

Device Condition	Group	N	Mean (SD)
Pre-Device	HP	16	14.01 (5.16)
	PCP	17	15.36 (4.59)
	Total	33	14.70 (4.85)
Device A	HP	16	6.23 (3.87)
	PCP	17	8.61 (5.39)
	Total	33	7.45 (4.80)
Device B	HP	16	6.91 (5.01)
	PCP	17	6.68 (4.77)
	Total	33	6.79 (4.80)
Device C	HP	16	6.42 (2.93)
	PCP	17	8.96 (5.05)
	Total	33	7.73 (4.30

Note. N=16; One HP participant was not included in this analysis due to incompletion of the VAPP

Figure 25

VAPP ALS mean scores between HP and PCP groups based on device condition Standard deviations are expressed by Error Bars



VAPP PRS scores. The third analysis which was based on *VAPP PRS* scores revealed a statistically significant difference of the multivariate analysis for within-subjects effect "*Device condition"* factor, $F(3, 93)=21.69$, $p=0.000$. This result suggests the participation restriction scores combined for both participant groups are different for pre-device use ($M=12.49$, $SD=5.68$) versus post-device use (Device A: $M=6.60$, $SD=4.88$; Device B: $M=6.70$, $SD=5.16$; Device C: $M=6.65$, $SD=4.50$). When examining between-subjects effect "*Group"* condition factor, $F(1, 31)=0.609$, $p=0.441$ there were no significant differences were found. This result indicates that the ratings provided by the participants with hypophonia (Pre-Device: $M=12.23$, $SD=5.56$; Device A: $M=5.34$, $SD=4.15$; Device B: $M=7.22$, $SD=5.93$; Device C: $M=5.40$, $SD=3.08$) were not significantly different from the ratings made by their primary communication partners during the same device conditions (Pre-Device: $M=12.72$, $SD=5.95$; Device A: $M=7.78$, $SD=5.33$; Device B: $M=6.22$, $SD=4.45$; Device C: $M=7.82$, $SD=5.38$). In addition, the *"Device condition" x "Group"* interaction was not significant $F(1, 31)=1.764$, $p=0.159$. This non-significant interaction indicates that each group gave a similar pattern of participation restriction ratings across the different device types. Table 33 presents the descriptive statistics for this subsection. Figure 26 presents the interaction between groups for ratings of pre-post participation restriction across devices.

Table 33

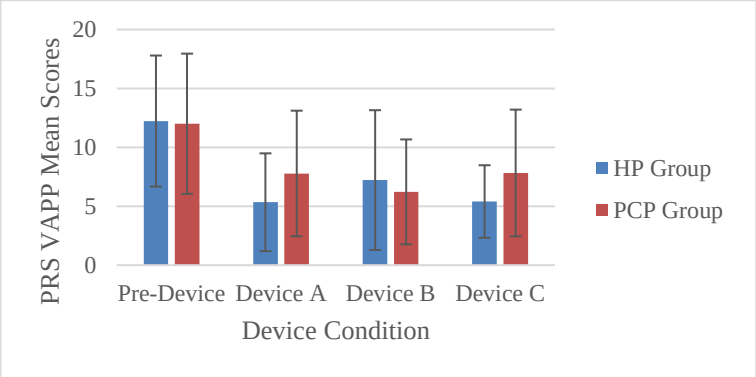
Descriptive statistics for VAPP PRS scores obtained for participants with hypophonia (HP) and their primary communication partners (PCP) across the device conditions

PRS VAPP	Group	N	Mean (SD)
Pre-Device	HP	16	12.23 (5.56)
	PCP	17	12.72 (5.95)
	Total	33	12.49 (5.60)
Device A	HP	16	5.34 (4.15)
	PCP	17	7.78 (5.33)
	Total	33	6.60 (4.88)
Device B	HP	16	7.22 (5.93)
	PCP	17	6.22 (4.45)
	Total	33	6.70 (5.16)
Device C	HP	16	5.40 (3.08)
	PCP	17	7.82 (5.38)
	Total	33	6.65 (4.50)

Note. N=16; One HP participant was not included in this analysis due to incompletion of the VAPP

Figure 26

VAPP PRS mean scores between HP and PCP groups based on device condition Standard deviations are expressed by Error Bars



These results of the RM ANOVAs suggest that there are no significant interactions across device conditions between the hypophonia group and their primary communication partners, however it is evident that these major VAPP categories are capturing pre-device condition versus post-device condition use.

RM MANOVA. A two-factor RM MANOVA was conducted to examine if there were differences across the devices between groups. There was one within-group independent variable "*Device Condition"* with four levels [Pre-Device, Device A, Device B, Device C] and one between-group independent variable "*Group*" with two levels [HP

participants (Group 1), PCP participants (Group 2)]. The individual category items on the VAPP served as the four dependent variables [C1VAPP, C3VAPP, C4VAPP, C5VAPP]. Based on this objective, the following comparison was made: to determine if category specific VAPP questions differ between participant groups across device conditions. Table 34 presents the descriptive statistics for two-factor RM MANOVA for the VAPP categories; C1, C3, C4, C5. The detailed results of this two-factor repeated measures MANOVA analysis are presented in Appendix S.

Results of the RM MANOVA reached significance for the within-subjects factor "*Device condition"*, $F(12, 230)=7.29$, $p=0.000$, $\eta^2_{partial}= 0.247$. The between-subjects factor "*Group"*, $F(4, 27)=0.215$, $p=0.928$, $\eta^2_{partial}= 0.031$ did not reach significance. The "*Device condition" x "Group"* interaction was not significant, $F(12, 19)=1.038$, $p=0.456$. $\eta^2_{partial}=0.396$. The descriptive statistics are presented in Table 34.

Table 34

Descriptive statistics of two-factor RM MANOVA for VAPP categories between device conditions across HP and PCP groups

VAPP subscale categories based on device	Group	N	Mean (SD)	VAPP subscale categories based on device	Group	N	Mean (SD)
C1 Pre-Device	HP	16	6.16 (2.41)	C4 Pre-Device	HP	16	20.76 (9.62)
	PCP	16	10.2 (19.00)		PCP	16	21.36 (7.51)
	Total	32	8.18 (13.48)		Total	32	21.06 (8.49)
C1 Device A	HP	16	3.20 (1.99)	C4 Device A	HP	16	12.59 (8.62)
	PCP	16	3.98 (2.18)		PCP	16	13.63 (8.83)
	Total	32	3.59 (2.09)		Total	32	13.11 (8.60)
C1 Device B	HP	16	3.82 (2.57)	C4 Device B	HP	16	12.81 (9.48)
	PCP	16	3.58 (2.65)		PCP	16	12.32 (7.49)
	Total	32	3.70 (2.57)		Total	32	12.56 (8.40)
C1 Device C	HP	16	3.60 (2.08)	C4 Device C	HP	16	11.82 (6.70)
	PCP	16	3.17 (2.08)		PCP	16	15.43 (8.86)
	Total	32	3.38 (2.06)		Total	32	13.62 (7.92)
C3 Pre-Device	HP	16	74.33 (22.19)	C5 Pre-Device	HP	16	42.06 (16.95)
	PCP	16	76.25 (22.87)		PCP	16	40.93 (12.39)
	Total	32	75.29 (22.19)		Total	32	41.50 (14.62)
C3 Device A	HP	16	38.79 (20.33)	C5 Device A	HP	16	26.83 (17.71)
	PCP	16	47.12 (24.17)		PCP	16	34.11 (21.97)
	Total	32	42.95 (22.37)		Total	32	30.47 (19.98)
C3 Device B	HP	16	40.43 (26.59)	C5 Device B	HP	16	28.96 (18.43)
	PCP	16	37.13 (22.23)		PCP	16	28.79 (16.77)
	Total	32	38.78 (24.17)		Total	32	28.88 (17.33)

C3 Device C	HP	16	39.01 (16.64)	C5 Device C	HP	16	23.45 (11.94)
	PCP	16	48.20 (25.25)		PCP	16	30.42 (17.09)
	Total	32	43.61 (22.12)		Total	32	26.93 (14.93)

**Note: N=32; One participant dyad not included due to incompletion of the VAPP*

Device Condition. Mauchly's test indicated that the assumption of sphericity was violated for Category 1 of the two-factor RM MANOVA, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity. The multivariate analysis for within-subjects effect *Device Condition* reached significance $F(12, 267)=5.492$, $p=0.000$. These results suggest there were significant differences for VAPP subscale categories across pre-device versus post-device conditions. Based on these significant "*Device condition"* results, univariate results were examined. When reviewing the univariate effects, VAPP subscale categories C3, C4 and C5 were all significant. No significant univariate main effects were found for VAPP subscale Category item 1: "*Self-perceived severity of speech symptoms*," $F(1.108, 33.231)=3.750$, $p=0.058$ $\eta^2_{partial} = 0.111$.

A significant univariate main effect was found for VAPP subscale Category 3: "*Effect on daily communication," F*(3, 90)=34.791, $p=0.000$, $\eta^2_{partial} = 0.537$; VAPP subscale Category 4: "*Effect on social communication," F*(3, 90)=15.118, $p=0.000$, $\eta^2_{partial} =0.355$; and VAPP subscale Category 5: "*Effect on emotion," F*(3, 90)=8.862, $p=0.000$, $\eta^2_{partial} =0.228$. These significant univariate effects can be interpreted by acknowledging that this device condition effect is most likely related to pre device versus post device conditions for both the HP and PCP groups. This device condition result is similar to the reported device conditions effect of the HP group analysis in Objective 1. The univariate statistics for the within-subjects factor "*Device condition*" are presented in Table 35 for each of the VAPP categories.

Table 35

VAPP Categories based on device condition for HP and PCP participants

VAPP Categories ***Device condition***	***F*(3, 90)**	***p***	$\eta^2_{partial}$
C1	$F(1.108, 33.231) = 3.750$*	.058	.111
C3	34.791	.000	.537
C4	15.118	.000	.355
C5	8.862	.000	.228

Post hoc comparisons. Post hoc comparisons using the LSD method, were completed for the VAPP category items with significant univariate main effects (VAPP items C3, C4, C5) to explore and examine the differences based on specific devices. The post hoc analyses focused on the three pre device versus post device comparisons (pre versus post-Device A, pre versus post-Device B, and pre versus post-Device C).

VAPP C3 (Device Condition): *Effect on daily communication*. The post hoc comparison related to C3VAPP, revealed significance across all devices. Firstly, significance was reached (p=0.000) when comparing the 'pre-device' condition (M=75.29, SD=22.19) versus the 'post-device A' condition (M=42.95, SD=22.37). Secondly, significance was reached (p=0.000) when comparing the 'pre-device' condition versus the 'post-device B' condition (M=38.78, SD=24.17). Finally, significance was reached (p=0.000) when comparing the 'pre-device' condition versus the 'post-device C' condition (M=43.61, SD=22.12). It is important to note, the interaction between groups for each device condition for this VAPP variable, did not reach significance F(3, 90)=1.050, p=0.374. This result suggests that the ratings across the three amplification device trial conditions are not sensitive to the effect on daily communication between groups, only across device conditions.

VAPP C4 (Device Condition): Effect on social communication. The post hoc comparison related to C4VAPP, indicated significance of total VAPPC4 across all devices. Firstly, significance was reached (p=0.000) when comparing the 'pre-device' condition (M=21.06, SD=8.49) versus the 'post-device A' condition (M=13.11, SD=8.60). Secondly, significance was reached (p=0.000) when comparing the 'pre-device' condition versus the 'post-device B' condition (M=12.56, SD=8.40). Finally, significance was reached (p=0.000) when comparing the 'pre-device' condition versus the 'post-device C' condition (M=13.62, SD=7.92). It is important to note, the interaction between groups for each device condition for this VAPP variable, did not reach significance F(3, 90)=0.108, p=0.550. This result suggests that the ratings of social communication do not vary between groups, only across device conditions.

VAPP C5 (Device Condition): Effect on emotion. The post hoc comparison related to C5VAPP, indicated significance of total VAPPC5 across all devices. Firstly, significance was reached (p=0.004) when comparing the 'pre-device' condition (M=41.50, SD=14.62) versus the 'post-device A' condition (M=30.47, SD=19.98). Secondly, significance was reached (p=0.001) when comparing the 'pre-device' condition versus the 'post-device B' condition (M=28.99, SD=17.33). Finally, significance was reached (p=0.000) when comparing the 'pre-device' condition versus the 'post-device C' condition (M=26.93, SD=14.93). It is important to note, the interaction between groups for each device condition for this VAPP variable, did not reach significance $F(3, 90)=1.057$, p=0.372. This result suggests that the self-ratings on emotion for individuals with hypophonia do not vary between groups, only across device conditions.

Group. When examining between-subjects effect *Group* condition factor**,** no significant values were detected for all VAPP category variables. Table 36 confirms there were no significant univariate effects detected. These results suggest that there is no significant difference in VAPP ratings between participants with hypophonia and their primary communication partners.

Table 36

Univariate results for the between-group factor (HP versus PCP groups) for each of the VAPP categories

VAPP Categories ***Group condition***	***F*(1, 30)**	***p***	$\eta^2_{partial}$
C1	.554	.463	.024
C3	.400	.532	.034
C4	.247	.623	.023
C5	.490	.490	.034

***Device Condition x Group*.** The within-subjects effect "*Device Condition" x "Group"* interaction did not reach significance, $F(12, 267)=0.664$, p=0.785. The univariate results of "*Device condition" x "Group"* are presented in Table 37. This non-significant interaction suggests that each group presented a similar pattern of VAPP ratings across the different device types for each of the categories. Table 37 presents the associated p-values for this interaction.

Table 37

Univariate interaction results for the Device Condition x Group interaction for each of the VAPP categories

VAPP Categories ***Device x Group condition***	***F*(3, 90)**	***p***	$\eta^2_{partial}$
C1	F (1.108, 33.23) = 0.750*	.406	.024
C3	1.050	.374	.034
C4	.108	.550	.023
C5	1.057	.372	.034

These results are consistent with the results of the Total VAPP analysis showing no significant interactions between groups for ratings of voice activity limitations and participation restrictions throughout these specific VAPP categories (*self-perceived severity of speech symptoms; effect on daily communication; effect on social communication; effect on emotion*). Significance differences were only achieved for pre-post activity limitation and participation restriction scores across the amplification devices.

3.5.3 Objective 3C: Psychosocial Impact of Assistive Devices.

Three separate two-factor RM MANOVAs were conducted to determine if ratings obtained from the PIADS differed for individuals between participant groups across device conditions. Based on this objective, comparisons examined whether self-rated '*Competence'* subscale scores of the PIADS differed within device conditions across participant groups; whether self-rated '*Adaptability'* subscale scores of the PIADS differed within device conditions across participant groups; and whether the '*Self-esteem'* subscale scores differed within device conditions across participant groups.

RM MANOVAs. The first RM MANOVA was based on the *PIADS Competence* subscale, the second RM MANOVA was based on the *PIADS Adaptability* subscale and the third RM MANOVA on the *PIADS Self-Esteem* subscale. For the first analysis, the dependent variable was the "*PIADS Competence*" subscale score, the second analysis, the dependent variable was the "*PIADS Adaptability"* subscale score, and the third analysis, the dependent variable was the "*PIADS Self-Esteem"* subscale score. For all three analyses, there was one within-group factor, "*Device*" with three levels [Device A,

Device B, Device C] and one between-group independent variable "Group" with two levels [HP participants (Group 1), PCP participants (Group 2)].

PIADS Competence subscale. The first analysis which was based on the *PIADS Competence* subscale score revealed no significance within-subject effect for '*Device'* condition $F(2, 62)=1.551$, $p=0.220$. This result suggests that participants with hypophonia did not rate the *PIADS Competence* subscale significantly different across the device conditions (Device A: $M=0.602$ $SD=0.54$; Device B: $M=0.627$, $SD=0.56$; Device C: $M=0.861$, $SD=0.87$). When examining the results of the between-subjects effect *Group* condition factor, $F(1, 31)=1.058$, $p=0.312$ there were no significant values detected. This result indicates that the ratings provided by the participants with hypophonia (Device A: $M=0.602$ $SD=0.54$; Device B: $M=0.627$, $SD=0.56$; Device C: $M=0.861$, $SD=0.87$) were similar to those ratings made by the primary communication partner group (Device A: $M=0.705$ $SD=0.73$; Device B: $M=1.03$, $SD=0.77$; Device C: $M=0.922$, $SD=0.68$) across all speech amplification devices. In addition, the group by device type interaction was not significant $F(2, 62)=0.920$, $p=0.404$. This non-significant interaction indicates that each group gave a similar pattern of *PIADS Competence* ratings and are not sensitive to device conditions. Table 38 presents the descriptive statistics for the RM MANOVA analysis based on *PIADS Competence* subscale scores.

Table 38

Descriptive statistics for PIADS Competence across device condition between participants with hypophonia and their primary communication partners

Device Condition	Group	N	Mean (SD)
Device A	HP	16	.602 (.54)
	PCP	17	.705 (.73)
	Total	33	.655 (.64)
Device B	HP	16	.627 (.56)
	PCP	17	1.03 (.77)
	Total	33	.838 (.70)
Device C	HP	16	.861 (.87)
	PCP	17	.922 (.68)
	Total	33	.893 (.77)

Note. HP= hypophonia participants, PCP=primary communication partners; N=16; One HP participant was not included in this analysis due to incompletion of the PIADS

PIADS Adaptability subscale. The second analysis which was based on the *PIADS Adaptability* sub-scale score revealed no significant within-subject effect for '*Device'* condition $F(2, 62)=0.561$, $p=0.573$. This result suggests that participants with hypophonia did not rate the *PIADS Adaptability* subscale significantly different across the device conditions (Device A: $M=0.747$, $SD=0.73$; Device B: $M=0.675$, $SD=0.576$ Device C: $M=0.900$, $SD=0.68$). When examining the results of the between-subjects effect *Group* condition factor, $F(1, 31)=0.037$, $p=0.849$ there were no significant values detected. This result indicates that the ratings provided by the participants with hypophonia (Device A: $M=0.747$, $SD=0.73$; Device B: $M=0.675$, $SD=0.576$; Device C: $M=0.900$, $SD=0.68$) were similar to those in the primary communication partner group (Device A: $M=0.685$, $SD=0.99$; Device B: $M=0.907$, $SD=0.91$; Device C: $M=0.862$, $SD=0.87$) across all speech amplification device types. In addition, the group by device type interaction was not significant, $F(2, 62)=0.550$, $p=0.580$. This non-significant interaction indicates that each group gave a similar pattern of *PIADS Adaptability* ratings and are not sensitive to device conditions. Table 39 presents the descriptive statistics for the mixed MANOVA analysis based on *PIADS Adaptability* subscale scores.

Table 39

Descriptive statistics for PIADS Adaptability across device condition between participants with hypophonia and their primary communication partners

Device Condition	Group	N	Mean (SD)
Device A	HP	16	.747 (.73)
	PCP	17	.685 (.99)
	Total	33	.715 (.86)
Device B	HP	16	.675 (.76)
	PCP	17	.907 (.91)
	Total	33	.794 (.84)
Device C	HP	16	.900 (.68)
	PCP	17	.862 (.87)
	Total	33	.881 (.77)

Note. HP= hypophonia participants, PCP=primary communication partners, N=16; One HP participant was not included in this analysis due to incompletion of the PIADS

PIADS Self-esteem subscale. The third analysis which was based on the *PIADS Self-esteem* subscale score revealed no significant within-subjects effect for '*Device'* condition $F(2, 62)=1.993$, $p=0.153$. This result suggests that participants with hypophonia did not rate the *PIADS Self-esteem* subscale significantly different across the device

conditions (Device A: *M*=0.476, *SD*=0.81; Device B: *M*=0.484, *SD*=0.66; Device C: *M*=0.669, *SD*=0.80). When examining the results of the between-subjects effect *Group*, *F*(1, 31)=0.215, *p*=0.646, there were no significant values detected. This result indicates that the ratings provided by the participants with hypophonia (Device A: *M*=0.476, *SD*=0.81; Device B: *M*=0.484, *SD*=0.66; Device C: *M*=0.669, *SD*=0.80) were similar to those in the primary communication partner group (Device A: *M*=0.352, *SD*=1.05; Device B: *M*=0.845, *SD*=0.91; Device C: *M*=0.735, *SD*=0.50) across all speech amplification device types. In addition, the group by device type interaction was not significant, *F*(2, 62)=1.216, *p*=0.299. This non-significant interaction indicates that each group gave a similar pattern of *PIADS Self-esteem* ratings and are not sensitive to device conditions. Table 40 presents the descriptive statistics for the RM MANOVA analysis based on *PIADS Self-esteem* subscale scores.

Table 40

Descriptive statistics for PIADS Self-esteem across device condition between participants with hypophonia and their primary communication partners

Device Condition	Group	N	Mean (SD)
Device A	HP	16	.476 (.81)
	PCP	17	.352 (1.05)
	Total	33	.412 (.93)
Device B	HP	16	.484 (.66)
	PCP	17	.845 (.91)
	Total	33	.670 (.80)
Device C	HP	16	.669 (.80)
	PCP	17	.735 (.50)
	Total	33	.703 (.65)

Note. HP= hypophonia participants, PCP=primary communication partners; N=16; One HP participant was not included in this analysis due to incompletion of the PIADS

3.6 Objective 4: To determine if a device hierarchy exists based on patient reported outcome measures related to communicative participation, and if this potential device hierarchy maps onto the device hierarchies proposed by Knowles et al. (2020) based on variables related to device preference, and performance-based objective speech measures of SNR and speech intelligibility.

The purpose of this objective was to determine if there was a device hierarchy using descriptive statistics based on each of the communicative participation outcome measures. The primary study from which our study is based on, Knowles et al., (2020), sought to establish device hierarchies based on *SNR*, *speech intelligibility* in adverse listening conditions, and *overall device selection* in the same group of participants as in our current study. Based on Knowles et al., (2020), the device hierarchy that emerged the for objective speech outcome measures of *SNR* and *speech intelligibility* was: Device C > Device B ≥ Device A > No Device, whereas, for *overall device selection* the hierarchy that emerged was: Device A > Device B & Device C. Taken together, these hierarchies suggest Device C was rated the highest for objective speech measures (i.e., SNR, speech intelligibility), while Device A was rated and selected as the most preferred device by our participants with hypophonia.

3.6.1 Objective 4A: To determine if a device hierarchy exists based on self-rated communicative effectiveness.

Total CES, *Mean CES*, and individual question scores contained on the Communicative Effectiveness Survey (Donovan et al., 2008) were used to determine device hierarchy(s) for self-rated communicative effectiveness. Based on the analysis of descriptive statistics for the *Total CES* and *Mean CES* scores, the device hierarchy that emerged for communicative effectiveness corresponded to: Device B > Device C > Device A > No Device. When examining the eight individual CES items, certain questions produced different device hierarchies. For example, Q1 (*Having a conversation with a family member or friends at home*) and Q6 (*Speaking to a friend when you are emotionally upset or you are angry*) produced the device hierarchy: Device C > Device B > Device A > No Device. Whereas Q2 (*Participating in conversation with strangers in a*

quiet place) produced the device hierarchy: Device B > Device A > Device C > No Device. For Q3 (*Conversing with a familiar person over the telephone*), and Q4 (*Conversing with a stranger over the telephone*), the device hierarchy was Device B > Device A > No Device > Device C. For Q7 (*Having a conversation while travelling in a car)* the device hierarchy produced was Device C > Device A > Device B > No Device. For CES Q5 (*Being a part of a conversation in a noisy environment*) and CES Q8 (*Having a conversation with someone at a distance*), the device hierarchy mirrored the hierarchy based on the *Total CES* and *Mean CES* scores: Device B > Device C > Device A. Taken together, it appears as if Device B or Device C produced the highest overall ratings for communicative effectiveness, whereas Device A was rated as producing the lowest communicative effectiveness scores across two of the three hierarchies that emerged from this analysis. When our hierarchies are compared to the hierarchy proposed by Knowles et al. (2020) for SNR and speech intelligibility (Device C > Device B ≥ Device A > No Device), our results mapped onto this hierarchy for CES Q1 and CES Q6, whereas all the other CES questions revealed Device B as the device with the highest ratings for communicative effectiveness, with Device C rated as second in the hierarchy. Interestingly, Knowles et al. (2020) proposed Device A as first in the hierarchy (i.e., Device A > Device B & Device C) for *overall device selected*. This hierarchy does not map onto any of our hierarchies related to communicative effectiveness. This is an interesting finding that will be expanded upon in the Discussion. Table 41 provides a visual representation of the device hierarchies and the corresponding CES questions.

Table 41

Communicative effectiveness device hierarchies

Device Hierarchy	CES Questions
Device B > Device C > Device A> No Device	*Total CES* *Mean CES* *Being a part of a conversation in a noisy environment (social gathering) (Q5)* *Having a conversation with someone at a distance (across a room) (Q8)*
Device C > Device B > Device A > No Device	*Having a conversation with a family member or someone at home (Q1)* *Speaking to a friend when you are emotionally upset or you are angry (Q6)*
Device B > Device A > Device C> No Device	*Participating in conversation with strangers in a quiet place (Q2)*
Device B > Device A > No Device > Device C	*Conversation with a familiar person over the telephone (Q3)* *Conversing with a stranger over the telephone (Q4)*
Device C > Device A > Device B > No Device	*Having a conversation while travelling in a car (Q7)*

3.6.2 Objective 4B: To determine if a device hierarchy exists based on self-rated voice activity and participation scores.

Total VAPP, VAPP ALS, VAPP PRS, and the four VAPP subscale categories derived from the Voice Activity and Participation Profile (Ma & Yiu, 2007) were analyzed to explore device hierarchy(s) for voice activity and participation. Two distinct device hierarchies emerged from this analysis based on descriptive statistics. The first device hierarchy that emerged was: Device C > Device A > Device B > No Device for *Total VAPP, Category 4: Effect on Social Communication,* and *Category 5: Effect on Emotion.* The second device hierarchy that emerged was: Device A > Device C > Device B > No Device for the Activity Limitation Score (*ALS*), the Participation Restriction Score (*PRS*), *Category 1: Self-perceived severity of speech problem,* and *Category 3: Effect on daily communication.* Taken together, it appears as if Device C or Device A produced the highest overall ratings for voice activity and participation, whereas Device B and No Device was rated as producing the lowest voice activity and participation scores across both hierarchies that emerged from this analysis.

When our hierarchies are compared to the hierarchy proposed by Knowles et al. (2020) for SNR and speech intelligibility (Device C > Device B ≥ Device A > No Device), our

hierarchy (Device C > Device A > Device B > No Device: *Total VAPP, C4: Effect on Social Communication, C6: Effect on Emotion*) did not exactly map onto Knowles' hierarchy for SNL and speech intelligibility, but what was similar across both hierarchies (i.e., both studies) was that Device C emerged as the device with the highest ratings. Similarly, although our second device hierarchy (Device A > Device C > Device B > No Device: VAPP *ALS*, VAPP *PRS, C1: Self-perceived severity of speech problem, C3: Effect on daily communication*) does not map exactly onto Knowles' hierarchy for *overall selected device* (Device A > Device B & Device C), what was similar across both hierarchies was that Device A emerged as the device with the highest ratings. These findings will be expanded upon in the Discussion. Table 42 provides a visual representation of the device hierarchies and the corresponding VAPP categories and scores.

Table 42

Voice activity and participation device hierarchies

Device Hierarchy	VAPP Categories
Device C > Device A > Device B > No Device	*Total VAPP* *Effect on social communication (C4)* *Effect on emotion (C5)*
Device A > Device C > Device B > No Device	*Activity Limitation Score (ALS)* *Participation Restriction Score (PRS)* *Self-perceived severity of speech problem (C1)* *Effect on daily communication (C3)*

3.6.3 Objective 4C: To determine if a device hierarchy exists based on self-rated scores relating to the psychosocial impact of using an amplification device.

PIADS Competence, Adaptability, and *Self-esteem* subscale categories derived from the Psychosocial Impact of Assistive Devices (Day & Jutai, 1996) were analyzed to explore device hierarchy(s) related to the psychosocial impact of using an assistive device. Two device hierarchies emerged from this analysis based on descriptive statistics. The first device hierarchy that emerged was: Device C > Device B > Device A for the *Competence* and *Self-esteem* subscales. The second device hierarchy that emerged was: Device C > Device A > Device B for the *Adaptability* subscale. Taken together, it

appears as if Device C consistently produced the highest overall ratings when examining the psychosocial impact of using an assistive device.

When our hierarchies are compared to the hierarchy proposed by Knowles et al. (2020) for SNR and speech intelligibility (Device C > Device B ≥ Device A > No Device), our device hierarchy for the PIADS *Competence* and *Self-esteem* subscales mapped exactly onto Knowles' hierarchy. Although our second hierarchy (Device C > Device A > Device B), was not an exact mapping onto Knowles' hierarchy, the results reveal that Device C emerged as the device with the highest ratings across both studies. Knowles' second hierarchy based on *overall device selection* (Device A > Device B & Device C) did not map onto any of our device hierarchies based on the PIADS. These findings will be expanded upon in the Discussion. Table 43 provides a visual representation of the device hierarchies and the corresponding PIADS subscales.

Table 43

Psychosocial impact device hierarchies

Device Hierarchy	PIADS Subscales
Device C > Device B > Device A	*Competence* *Self-Esteem*
Device C > Device A > Device B	*Adaptability*

In summary, there is variability in the device hierarchy results across the three patient reported outcome measures. The results revealed that Device A emerged first in the hierarchy for several items related to the Voice Activity and Participation Profile, but this device did not emerge first in the hierarchy for any of other patient reported outcome measures analyzed (i.e., CES, PIADS). Device B emerged first in the hierarchy for the majority of items on the Communicative Effectiveness Survey, but this device did not emerge first in the hierarchy for any of the other patient reported outcome measures analyzed. Device C emerged first in the hierarchy across all of the PIADS subscales and emerged as first in the hierarchy across several categories of each of the patient reported outcome measures analyzed, suggesting Device C may be more effective in capturing a broader range of participation/psychosocial outcomes. Table 44 provides a visual

representation of the device hierarchies' and corresponding patient reported outcome measures.

Table 44

Summary of outcome measure items and corresponding device hierarchies, with emphasis on highest ratings of each device

Device Hierarchy	Outcome measure items
Device A	
Device A > Device C > Device B > No Device	*VAPP Activity Limitation Score* *VAPP Participation Restriction Score* *VAPP C1: Self-perceived severity of speech problem* *VAPP C3: Effect on daily communication*
Device B	
Device B > Device A > Device C > No Device	*CES Q2: Participating in conversation with strangers in a quiet place*
Device B > Device A > No Device > Device C	*CES Q3: Conversing with a familiar person over the telephone* *CES Q4: Conversing with a stranger over the telephone*
Device B > Device C > Device A > No Device	*CES Total* *CES Mean* *CES Q5: Being a part of a conversation in a noisy environment (social gathering)* *CES Q8: Having a conversation with someone at a distance (across a room)*
Device C	
Device C > Device A > Device B > No Device	*CES Q7: Having a conversation while travelling in a car* *VAPP Total* *VAPP C4: Effect on social communication* *VAPP C5: Effect on emotion* *PIADS Adaptability*
Device C > Device B > Device A> No Device	*CES Q1: Having a conversation with a family member or friends at home* *CES Q6: Speaking to a friend when you are emotionally upset, or you are angry* *PIADS Competence* *PIADS Self-esteem*

In comparison to Knowles and colleagues (2020), there are differences among our device hierarchies and ratings for *overall selection of device*. In our study, the results revealed that Device C emerged as the device that produced the highest ratings (i.e., placed first in the hierarchy) across the most outcome measures (e.g., CES Q1, CES Q6, CES Q7, CES Q8; VAPP Total, VAPP C4, VAPP C5; and all PIADS subscales). Device C also maps onto Knowles' hierarchies related to measures of SNR and speech intelligibility,

however, the *overall device selection* hierarchy proposed by Knowles et al. (2020) Device A > Device B & Device C, did not map exactly onto any of our device hierarchies based on patient reported outcome measures. A further evaluation of this *overall selection* hierarchy will be included in the next objective. Table 45 provides a visual representation of the device hierarchies in our study compared to the device hierarchies reported by Knowles et al. (2020).

Table 45

Comparison of device hierarchies across studies

Device Hierarchy	Current Study	Knowles et al. (2020) Study
Device A		
Device A > Device B & Device C		Overall Selection of Device
Device A > Device C > Device B > No Device	*VAPP Activity Limitation Score* *VAPP Participation Restriction Score* *VAPP C1: Self- perceived severity of voice problem* *VAPP C2: Effect on job*	
Device B		
Device B > Device A > Device C > No Device	*CES Q2: Participating in conversation with strangers in a quiet place*	
Device B > Device A > No Device > Device C	*CES Q3: Conversing with a familiar person over the telephone* *CES Q4: Conversing with a stranger over the telephone*	
Device B > Device C > Device A > No Device	*CES Total* *CES Mean* *CES Q5: Being a part of a conversation in a noisy environment (social gathering)* *CES Q8: Having a conversation with someone at a distance (across a room)*	
Device C		
Device C > Device A > Device B > No Device	*CES Q7* *VAPP Total* *VAPP C4: Effect on social communication* *VAPP C5: Effect on emotion* *PIADS Adaptability*	
Device C > Device B > Device A> No Device	*CES Q1: Having a conversation with a family member or friends at home* *CES Q6: Speaking to a friend when you are emotionally upset or you are angry* *PIADS Competence* *PIADS Self-esteem*	SNR & Speech Intelligibility

3.7 Objective 5: To determine if final device selection is associated with patient-reported outcome data obtained in the three device trial periods.

The purpose of this objective was to explore if participants chose a device based on self-rated communicative effectiveness scores, voice activity and participation scores, and psychosocial impact scores during the device trial periods. Specifically, the aim of this objective was to determine if there were any differences in self-rated communicative effectiveness, voice activity and participation, and the psychosocial impact of device use between participants that chose to select and purchase a device versus participants that did not choose to select or purchase a device.

3.7.1 Objective 5A: Communicative Effectiveness**.**

Two, two-factor RM ANOVAs and a two-factor RM MANOVA were conducted to determine differences between HP participants (*Selectors* vs *Non-selectors*) across device conditions based on CES scores.

Two-factor RM ANOVAs. The first two-factor RM ANOVA was based on *Total CES* scores, and the second two-factor RM ANOVA was based on *Mean CES* scores. For the first analysis, the dependent variable was "*Total CES*" and for the second analysis, the dependent variable was "*Mean CES*." For both analyses, there was one within-group independent factor, called "Device condition," with four levels [Pre-Device, Device A, Device B, Device C] and one between-group independent factor called "*Group*" with two levels [Selectors (Group 1), Non-Selectors (Group 2)]. Based on this objective, the following comparisons were made: to determine whether *Total* and *Mean CES* scores differed within device conditions across selection groups (i.e., *Selectors* vs *Non-selectors*).

Total CES scores. The first analysis which was based on *Total CES* scores did not reveal a statistically significant difference of *Total CES scores* for the within-subjects factor "*Device condition"*, $F(3, 45)=2.745$, $p=0.054$. However, given that the p-value was close to reaching significance, post-hoc evaluations related to differences in device

conditions were performed. The within-subjects interaction "*Device condition" x "Selectors",* indicated non-significant results $F(3, 45)=1.460$, $p=0.238$. This interaction result suggests that the pattern of differences between the four device conditions was similar across the *Selector* and *Non-selector* groups for the *Total CES* scores. When examining the between-subjects factor (*Selectors vs Non-Selectors),* a significant result was found $F(1, 15)=7.370$, $p=0.016$. This result indicates that the *Selector* group had significantly lower ($M=19.62$, $SD=0.70$) *Total CES* scores than the *Non-selector* group ($M=23.15$, $SD=1.09$) across the device conditions.

Further post-hoc evaluation of the significance in the *Device condition* indicated that the 'Pre-device' condition ($M=17.76$, $SD=5.90$) was significantly lower ($p=0.031$) than 'Device C' ($M=21.53$, $SD=4.28$), but the 'pre-device' condition was not significantly different from 'Device A' ($M=21.18$, $SD=3.67$; $p=0.152$) or 'Device B' ($M=22.18$, $SD=4.57$; $p=0.069$). Table 46 presents the descriptive statistics for the *Total CES* scores obtained for the *Selector* and *Non-selector* groups in each device condition. Figure 27 presents the mean *Total CES* results for the *Selector* and *Non-selector* groups in each of the device conditions.

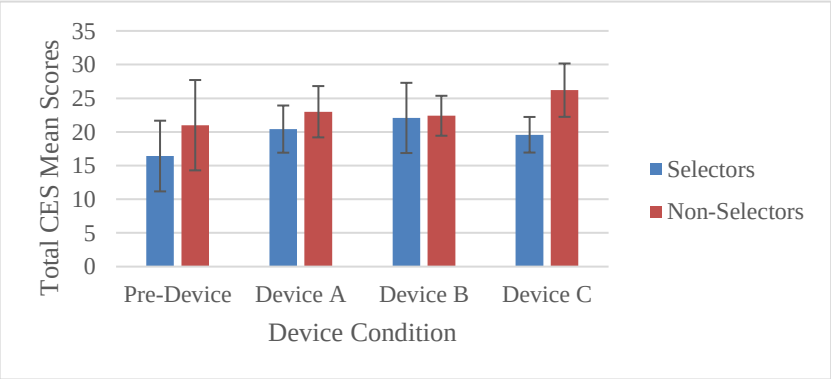
Table 46

Descriptive statistics for Total CES obtained for the selector and non-selector groups relative to the device condition examined in the two factor RM ANOVA analysis

Device Condition	Group	N	Mean (SD)
Pre-Device	Selectors	12	16.42 (5.24)
	Non-selectors	5	21.00 (6.70)
	Total	17	17.76 (5.90)
Device A	Selectors	12	20.42 (3.50)
	Non-selectors	5	23.00 (3.80)
	Total	17	21.18 (3.67)
Device B	Selectors	12	22.08 (5.21)
	Non-selectors	5	22.40 (2.96)
	Total	17	22.18 (4.57)
Device C	Selectors	12	19.58 (2.64)
	Non-selectors	5	26.20 (3.96)
	Total	17	21.53 (4.28)

Figure 27

Total CES mean scores for the Selector and Non-selector groups based on device condition
Standard deviations are expressed by Error Bars.



Mean CES scores. The second analysis which was based on *Mean CES* scores did not reveal a statistically significant difference of *Mean CES scores* for the within-subjects factor "*Device condition"*, $F(3, 45)=2.745$, $p=0.054$. However, given that the p-value was close to reaching significance, post-hoc evaluations related to differences in device conditions were performed. The within-subjects interaction "*Device condition" x "Selectors"* condition factor, also indicated non-significant results ($F(3, 45)=1.460$, $p=0.238$). This interaction result suggests that the pattern of differences between the four device conditions was similar across the *Selector* and *Non-selector* groups for the *Mean CES* scores. When examining the between-subjects factor (*Selectors* vs *Non-Selectors*), a significant result was found ($F(1, 15)=7.370$, $p=0.016$). This result indicates that the *Selector* group had significantly lower ($M=2.45$, $SD=0.08$) *Mean CES* scores than the *Non-Selector* group ($M=2.89$, $SD=0.13$) across the device conditions. Table 47 presents the descriptive statistics for the *Mean CES* scores.

Further post-hoc evaluation of the significance in the *Device condition* indicated that the 'Pre-device' condition ($M=2.22$, $SD=0.73$) was significantly lower ($p=0.031$) than 'Device C' ($M=2.69$, $SD=0.53$), but the 'pre-device' condition was not significantly different from 'Device A' ($M=2.64$ $SD=0.49$; $p=0.152$) or 'Device B' ($M=2.77$ $SD=0.57$; $p=0.069$). Table 46 presents the descriptive statistics for the *Mean CES* scores obtained for the *Selector* and *Non-selector* groups in each device condition. Figure 27

presents the *Mean CES* results for the *Selector* and *Non-selector* groups in each of the device conditions.

Table 47

Descriptive statistics for Mean CES obtained for the Selector and Non-selector based on device condition

Device Condition	Group	N	Mean (SD)
Pre-Device	Selectors	12	2.05 (.65)
	Non-selectors	5	2.62 (.83)
	Total	17	2.22 (.73)
Device A	Selectors	12	2.55 (.43)
	Non-selectors	5	2.87 (.47)
	Total	17	2.64 (.45)
Device B	Selectors	12	2.76 (.65)
	Non-selectors	5	2.80 (.37)
	Total	17	2.77 (.57)
Device C	Selectors	12	2.44 (.33)
	Non-selectors	5	3.27 (.49)
	Total	17	2.69 (.53)

Two-factor RM MANOVA. A two-factor RM MANOVA was conducted to examine if there were differences between selector groups across device conditions. There was one within-group factor, "*Device condition*" with four levels [Pre-Device, Device A, Device B, Device C] and one between-group factor, "*Group*" with two levels [Selectors (1), Non-Selectors (2)]. The individual items on the CES served as the eight dependent variables [Q1CES, Q2CES, Q3CES, Q4CES, Q5CES, Q6CES, Q7CES, Q8CES].

Results of the two-factor RM MANOVA for CESQ1-Q8, the within-subjects factor "*Device condition"*, $F(24, 84)=1.647$, $p=0.050$ yielded significant results, while the "*Device condition" x "Selectors"* condition interaction, $F(24, 84)=1.254$, $p=0.215$ revealed non-significant results. When examining the between-group factor (*Selectors vs Non-selectors)*, no significant results were reached, $F(8, 5)=3.218$, $p=0.107$. Based on the significant within-subjects factor, *Device condition,* the separate univariate effects of the eight CES questions were examined. The descriptive statistics are presented in Table 48 and the univariate statistics are presented in Table 49. The detailed results of this two-factor repeated measures MANOVA analysis are presented in Appendix T.

Table 48

Descriptive statistics for CES items Q1-Q8 based on device condition between Selectors and Non-Selectors

CES Q1-Q4	Group	N	Mean	Std. Deviation	CES Q5-Q8	Group	N	Mean	Std. Deviation
Q1 Pre-Device	Selectors	10	2.90	.738	Q5 Pre-Device	Selectors	10	1.80	.789
	Non-selectors	4	3.00	.816		Non-selectors	4	2.25	1.258
	Total	14	2.93	.730		Total	14	1.93	.917
Q1 Device A	Selectors	10	3.20	.632	Q5 Device A	Selectors	10	2.20	.789
	Non-selectors	4	3.00	.816		Non-selectors	4	3.00	.816
	Total	14	3.14	.663		Total	14	2.43	.852
Q1 Device B	Selectors	10	3.00	.816	Q5 Device B	Selectors	10	3.00	.667
	Non-selectors	4	3.50	.577		Non-selectors	4	2.75	.500
	Total	14	3.14	.770		Total	14	2.93	.616
Q1 Device C	Selectors	10	3.10	.738	Q5 Device C	Selectors	10	2.60	.516
	Non-selectors	4	3.50	.577		Non-selectors	4	3.25	.500
	Total	14	3.21	.699		Total	14	2.79	.579
Q2 Pre-Device	Selectors	10	2.40	.843	Q6 Pre-Device	Selectors	10	1.80	.632
	Non-selectors	4	2.50	1.291		Non-selectors	4	2.50	1.291
	Total	14	2.43	.938		Total	14	2.00	.877
Q2 Device A	Selectors	10	2.70	.675	Q6 Device A	Selectors	10	2.00	.816
	Non-selectors	4	3.00	.816		Non-selectors	4	2.50	1.291
	Total	14	2.79	.699		Total	14	2.14	.949
Q2 Device B	Selectors	10	2.70	.949	Q6 Device B	Selectors	10	2.70	.823
	Non-selectors	4	3.25	.500		Non-selectors	4	2.50	1.291
	Total	14	2.86	.864		Total	14	2.64	.929
Q2 Device C	Selectors	10	2.50	.850	Q6 Device C	Selectors	10	2.50	.527
	Non-selectors	4	3.25	.957		Non-selectors	4	3.25	.500
	Total	14	2.71	.914		Total	14	2.71	.611
Q3 Pre-Device	Selectors	10	2.40	.966	Q7 Pre-Device	Selectors	10	2.00	.943
	Non-selectors	4	3.00	.816		Non-selectors	4	2.75	.957
	Total	14	2.57	.938		Total	14	2.21	.975
Q3 Device A	Selectors	10	2.70	.823	Q7 Device A	Selectors	10	2.80	.632
	Non-selectors	4	2.50	.577		Non-selectors	4	3.00	.816
	Total	14	2.64	.745		Total	14	2.86	.663
Q3 Device B	Selectors	10	2.70	.483	Q7 Device B	Selectors	10	3.00	.816
	Non-selectors	4	3.25	.500		Non-selectors	4	2.25	.500
	Total	14	2.86	.535		Total	14	2.79	.802
Q3 Device C	Selectors	10	1.70	.675	Q7 Device C	Selectors	10	3.00	.667
	Non-selectors	4	3.50	.577		Non-selectors	4	3.00	1.155

	Total	14	2.21	1.051		Total	14	3.00	.784
Q4 Pre-Device	Selectors	10	1.90	1.101	Q8 Pre-Device	Selectors	10	1.90	.738
	Non-selectors	4	3.25	.500		Non-selectors	4	2.50	1.291
	Total	14	2.29	1.139		Total	14	2.07	.917
Q4 Device A	Selectors	10	2.20	.632	Q8 Device A	Selectors	10	2.60	.843
	Non-selectors	4	2.75	.500		Non-selectors	4	3.00	.816
	Total	14	2.36	.633		Total	14	2.71	.825
Q4 Device B	Selectors	10	2.50	.527	Q8 Device B	Selectors	10	3.40	.966
	Non-selectors	4	2.75	.500		Non-selectors	4	3.25	.500
	Total	14	2.57	.514		Total	14	3.36	.842
Q4 Device C	Selectors	10	1.50	.707	Q8 Device C	Selectors	10	3.10	.316
	Non-selectors	4	3.00	.816		Non-selectors	4	3.75	.500
	Total	14	1.93	.997		Total	14	3.29	.469

Table 49

Effect of Device condition of two-factor RM MANOVA for CES items Q1-Q8 for Selector and Non-selector groups

Device Condition CES Items	***F*(3, 36)**	***p***	$\eta^2_{partial}$
Q1	.478	.699	.038
Q2	.955	.425	.074
Q3	.955	.654	.044
Q4	.547	.671	.042
Q5	4.237	.012	.261
Q6	1.875	.151	.135
Q7	1.751	.174	.127
Q8	7.974	.000	.399

***Device Condition*.** Based on the significant multivariate effect for the within-subjects factor "*Device condition*", $F(24, 84)=1.647$, $p=0.050$, the univariate effects were analyzed for each of the eight CES questions. From these univariate results, main effects did not reach significance for CES questions 1, 2, 3, 4, 6, and 7. A significant univariate main effect was found for CES question 5 "*Being a part of a conversation in a noisy environment (social gathering)", F(*3, 36)=4.237, $p=0.012$, $\eta^2_{partial}=0.261$. A significant univariate main effect was also found for CES question 8 *"Having a conversation with someone at a distance (across a room)", F*(3, 36)=7.974, $p=0.000$, $\eta^2_{partial}=0.399$.

Post hoc comparisons (Device Condition). Post hoc comparisons were completed for the CES questions with significant univariate main effects (CES questions 5 and 8) to determine the differences based on specific devices. The post hoc analyses using the LSD method, focused on the three pre device versus post device comparisons (Pre versus Post device A, Pre versus Post device B, and Pre versus Post device C).

CES Q5 (Device Condition). The post hoc comparison related to total *Device* Q5CES: *Being a part of a conversation in a noisy environment (social gathering),* indicated that the 'pre-device' condition (M=1.93, SD=0.97) was significantly lower (p=0.027) than 'Device B' (M=2.93, SD=0.66; p=0.023) and 'Device C' (M=2.79, SD=0.57; p=0.027). This result suggests Devices B and C were rated as more effective amplification devices, in comparison to the pre-device condition, when in an individual is a part of a conversation in a noisy environment.

CES Q8 (Device Condition). The post hoc comparison related to total *Device* Q8CES: *Having a conversation with someone at a distance (across a room),* indicated that the 'pre-device' condition (M=2.07, SD=0.91) was significantly lower (p=0.004) than 'Device B' (M=3.36, SD=0.84) and significantly lower (p=0.002) than 'Device C'*(*M=3.29, SD=0.46). These results suggest that Devices B and C are rated as more effective amplification devices, in comparison to the pre-device trial, when an individual is having a conversation with another person at a distance.

***Selectors*.** Based on the significant multivariate effect for the within-subjects factor, the between-group factor (*Selectors* vs *Non-selectors*) was examined. There were no significant results reached, $F(8,5)=3.218$, p=0.107, however the univariate results related to the between-subjects factor (*Selectors vs Non-selectors)* was examined further for each of the CES questions (Q1-Q8). These univariate results are shown in Table 50.

Table 50

Univariate results related to the between group factor (Selectors vs Non-selectors) for CES items Q1-Q8

Selectors CES items	***F*(1,12)**	***p***	$\eta^2_{partial}$
Q1	1.407	.259	.105
Q2	1.978	.185	.141
Q3	35.764	.000	.749
Q4	29.187	.000	.709
Q5	2.513	.139	.173
Q6	2.710	.126	.184
Q7	.028	.871	.002
Q8	1.513	.242	.112

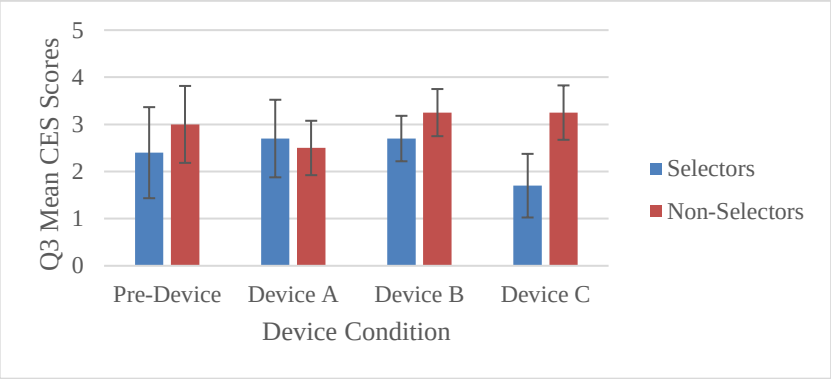
From these univariate results, main effects did not reach significance for CES questions 1, 2, 5, 6, 7, and 8. When reviewing the univariate effects, a significant univariate main effect was found for CES question 3: "*Conversing with a familiar person over the telephone",* ($F(1, 12)=35.764$, $p=0.000$, $\eta^2_{partial}=0.749$), and CES question 4: "*Conversing with a stranger over the telephone"* ($F(1, 12)=29.187$, $p=0.000$, $\eta^2_{partial}=0.709$).

Post hoc comparisons (Selectors). Post hoc comparisons were completed for the CES questions with significant univariate main effects (CES questions: 3, 4) to determine the differences based on specific devices. The post hoc analyses focused on the comparison across groups (*Selectors* versus *Non-selectors*).

The post hoc comparison for CES question 3 indicated that the *Selector* group had a significantly ($p=0.000$) lower score ($M=2.37$, $SD=0.06$) than the *Non-selector* group ($M=3.06$, $SD=0.09$). Figure 28 represents the mean CES Q3 results for the groups. It is interesting to note that, unlike the *Non-selector* group, the *Selector* group showed a lower CES question Q3 score for "Device C condition" relative to the "Pre-device condition" and the "Device A" and "Device B" conditions. These results suggests that for communicative contexts involving the telephone (Q3: *Conversing with a familiar person over the telephone)* the *Selector* group rated themselves as less effective when using "Device C". The potential relationship between communicative effectiveness, specific devices, and use of the telephone will be discussed further in the next chapter.

Figure 28

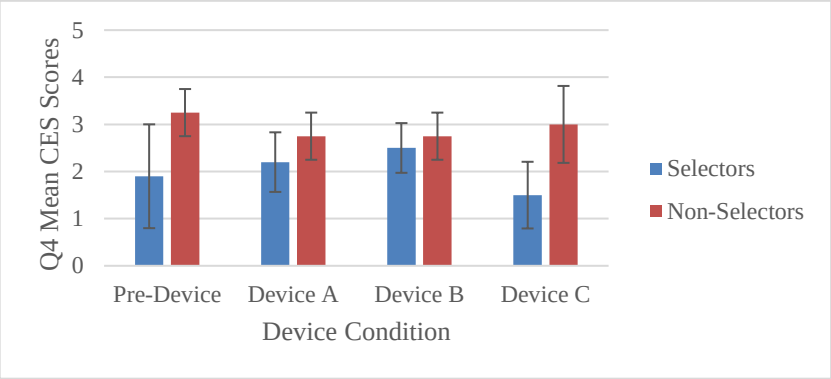
Q3CES mean scores for Selector and Non-selector groups
Standard deviations are expressed by Error Bars



The post hoc comparison for CES question 4: "*Conversing with a stranger over the telephone"* indicated that the *Selector* group had a significantly lower (p=0.000) CES Q4 score (M=2.02, SD=0.09) compared to the *Non-selector* group (M=2.93, SD=0.14). Figure 29 shows the mean CES Q4 scores for the *Selector* and *Non-selector* groups in each of the device conditions. It is interesting to note that, unlike the Non-selector group, the Selector group showed a lower CES Q4 score for "Device C" condition relative to the "Pre-device" condition and the "Device A" and "Device B" conditions. This result suggests that for a communicative context involving the telephone (Q4: *Conversing with a stranger over the telephone)* the *Selector* group rated themselves as less effective when using "Device C". Thus, the pattern of results for CES Q4 is very similar to those found for CES Q3. As previously mentioned, the potential relationship between communicative effectiveness, specific devices, and use of the telephone will be discussed further in the next chapter.

Figure 29

Q4CES mean scores for Selector and Non-selector groups
Standard deviations are expressed by Error Bars



Univariate Interaction analysis for Device Condition x Selector Groups. Based on the significant multivariate effect for the within-subjects factor, the interaction of the condition "*Device condition*" x "*Selectors*" revealed non-significant results ($F(24, 84)=1.254$, $p=0.215$). The univariate results for the interaction involving the "*Device condition" x "Selector Groups"* are presented in Table 51.

Table 51

Univariate Interaction results for the Device conditions x Selector groups interaction related to CES items Q1-Q8

Device x Selectors CES Items	***F*(3, 36)**	***p***	$\eta^2_{partial}$
Q1	.478	.699	.038
Q2	.320	.782	.029
Q3	2.976	.044	.199
Q4	1.738	.177	.126
Q5	1.339	.277	.100
Q6	.815	.494	.064
Q7	2.118	.116	.150
Q8	.844	.479	.066

The univariate *"Device condition x Group"* interactions did not reach significance for CES questions 1, 2, 4, 5, 6, 7, 8. A significant univariate interaction was found for CES question 3: "*Conversing with a familiar person over the telephone", F*(3, 36)=2.976, $p=0.044$, $\eta^2_{partial}=0.199$. This interaction suggests that for communicative contexts

involving the telephone (Q3: *Conversing with a familiar person over the telephone)* the *Selector* and *Non-selector* groups demonstrated different patterns in how they rated communicative effectiveness related to conversing on the telephone with a familiar person across the device conditions. Of particular interest, is the group difference related to communicative effectiveness when using "Device C". The potential relationship between communicative effectiveness, specific devices such as Device C, and use of the telephone will be discussed further in the next chapter.

3.7.2 Objective 5B: Voice Activity and Participation.

Three, two-factor RM ANOVAs and a single two-factor RM MANOVA were conducted to determine differences between HP participant groups (*Selectors* vs *Non-selectors*) across device conditions based on VAPP scores.

Two-factor RM ANOVAs. The first two-factor RM ANOVA was based on *Total VAPP* scores, the second two-factor RM ANOVA was based on *VAPP ALS* scores, and the third two-factor RM ANOVA was based on *VAPP PRS* scores. For all three analyses, there was one within-group factor "*Device condition*" with four levels [Pre-Device, Device A, Device B, Device C and one between-group factor "*Group*" with two levels [Selectors (Group 1), Non-Selectors (Group 2)]. For the first analysis, the dependent variable was "*Total VAPP,*" the second analysis, the dependent variable was "*VAPP ALS,*" and the third analysis, the dependent variable was "*PRS VAPP."* Based on this objective, the following comparisons were made: to determine whether *Total VAPP* scores differed within device conditions across selection groups (i.e., *Selectors* vs *Non-selectors*).

Total VAPP scores. The first analysis which was based on *Total VAPP* scores revealed a statistically significant result of the *Total VAPP* for the within-subjects factor "*Device condition"*, $F(3, 42)=10.81$, $p=0.000$. The within-subjects interaction "*Device condition" x "Selectors"* indicated non-significant results *(*$F(3, 42)=0.813$, $p=0.494$). This interaction result suggests that the pattern of differences between the four device conditions was similar across the *Selector* and *Non-selector* groups for the *Total VAPP* scores. When examining the between-subjects factor (*Selectors vs Non-selectors),* a

significant result was found, $F(1, 14)=8.467$, $p=0.011$. This result indicates that the *Selector* group had significantly higher ($M=109.84$, $SD= 8.27$) *Total VAPP* scores than the *Non-selector* group ($M=61.65$, $SD=14.34$) across the device conditions. It is important to note that higher *Total VAPP* scores are associated with greater activity limitations and participation restrictions (i.e., higher scores are worse), and lower *Total VAPP* scores are associated with less activity limitations and participation restrictions.

Further post-hoc evaluation of *Device condition* indicated that the 'Pre-device' condition ($M=145.80$, $SD=50.49$) was significantly higher than 'Device A' ($M=81.43$, $SD=41.47$; $p=0.000$); significantly higher than 'Device B' ($M=86.04$, $SD=51.75$; $p=0.004$); and significantly higher than 'Device C' ($M=77.89$, $SD=28.32$; $p=0.001$). Table 52 presents the descriptive statistics obtained for the *Selector* and *Non-selector* groups in each of the device conditions. Figure 30 presents the mean *Total VAPP* results for the *Selector* and *Non-selector* groups in each of the device conditions.

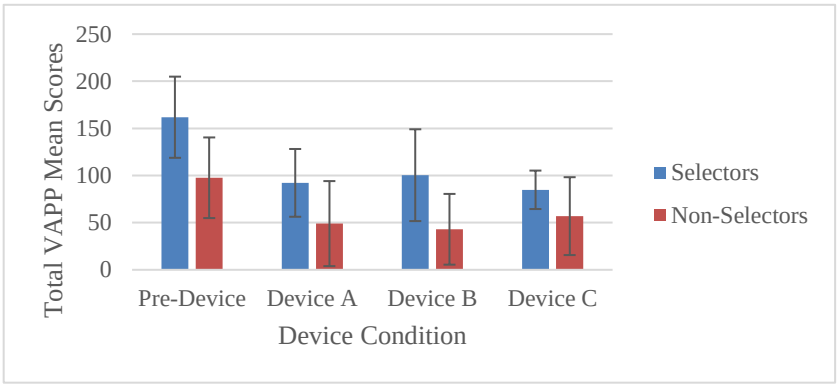
Table 52

Descriptive statistics Total VAPP obtained for the Selector and Non-selector groups relative to the device condition examined in the two factor RM ANOVA analysis

Device Condition	N	Group	Mean (SD)
Pre-Device	12	Selectors	161.85 (43.04)
	4	Non-selectors	97.65 (42.76)
	16	Total	145.80 (50.49)
Device A	12	Selectors	92.23 (35.95)
	4	Non-selectors	49.02 (45.09)
	16	Total	81.43 (41.47)
Device B	12	Selectors	100.39 (48.69)
	4	Non-selectors	43.00 (37.52)
	16	Total	86.04 (51.75)
Device C	12	Selectors	84.87 (20.40)
	4	Non-selectors	56.95 (41.29)
	16	Total	77.89 (28.32)

Figure 30

Total VAPP mean scores for Selector and Non-selector groups based on device condition Standard deviations are expressed by Error Bars



VAPP ALS scores. The second analysis which was based on *VAPP ALS* scores revealed a statistically significant result of the within-subjects factor "*Device condition*", $F(3, 42)=12.11$, $p=0.000$. The within-subjects interaction "*Device condition x Selectors"* revealed non-significant results, $F(3, 42)=0.998$, $p=0.403$. This interaction result suggests that the pattern of differences among the four device conditions was similar across the *Selector* and *Non-selector* groups for the *VAPP ALS* scores. When examining the between-subjects factor (*Selectors vs Non-selectors)* a significant result was found, $F(1, 14)=6.691$, $p=0.022$. This result indicates that the *Selector* group had significantly higher ($M=9.43$, $SD=0.80$) *VAPP ALS* scores than the *Non-selector* group ($M=5.27$, $SD=1.39$) across the device conditions. It is important to note that higher *VAPP Activity Limitation Scale* scores are associated with greater activity limitations, and lower *VAPP Activity Limitation Scale* scores are associated with lesser activity limitations.

Further post-hoc evaluation of *Device condition* indicated that the 'Pre-device' condition ($M=14.01$, $SD=5.16$) was significantly higher than 'Device A" ($M=6.23$, $SD=3.87$; $p=0.000$); significantly higher than 'Device B' ($M=6.91$, $SD=5.91$; $p=0.001$); and significantly higher than 'Device C' ($M=6.42$, $SD=2.93$; $p=0.001$). Table 53 presents the descriptive statistics for *VAPP ALS* scores obtained for the *Selector* and *Non-selector* group in each device condition. Figure 31 presents the mean *ALS VAPP* results for the *Selector* and *Non-selector* groups in each of the device conditions.

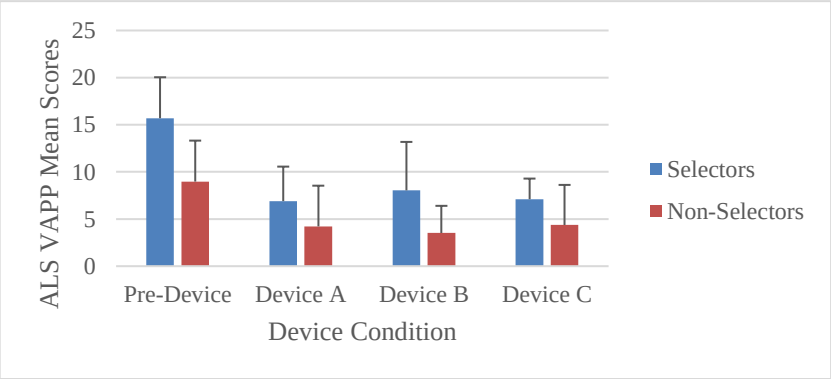
Table 53

Descriptive statistics for VAPP ALS obtained for the Selector and Non-selector groups relative to the device condition examined in the two-factor RM ANOVA analysis

Device Condition	N	Group	Mean (SD)
Pre-Device	12	Selectors	15.69 (4.35)
	4	Non-selectors	8.97 (4.35)
	16	Total	14.01 (5.16)
Device A	12	Selectors	6.90 (3.66)
	4	Non-selectors	4.22 (4.32)
	16	Total	6.23 (3.87)
Device B	12	Selectors	8.04 (5.14)
	4	Non-selectors	3.52 (2.88)
	16	Total	6.91 (5.91)
Device C	12	Selectors	7.10 (2.19)
	4	Non-selectors	4.37 (4.25)
	16	Total	6.42 (2.93)

Figure 31

VAPP ALS mean scores for Selector and Non-selector groups based on device condition Standard deviations are expressed by Error Bars



VAPP PRS scores. The third analysis which was based on *VAPP PRS* scores revealed a statistically significant result for the within-subjects factor *"Device condition", F*(3, 42)=8.783, *p*=0.000. The within-subjects interaction "*Device condition x Selectors"* revealed non-significant results, *F*(3, 42)=0.804, *p*=0.499. This interaction result suggests that the pattern of differences among the four device conditions was similar across the *Selector* and *Non-selector* groups for the total *VAPP PRS* scores. When examining the between-subjects factor (*Selectors vs Non-Selectors*), no significant results were found, *F*(1, 14)=2.88, *p*=0.116. Table 49 presents the descriptive statistics for the *VAPP PRS* scores. Figure 30 presents the interaction between groups for ratings of pre-

post participation restriction scores across devices. It is important to note that higher *VAPP Participation Restrictions Scale* scores are associated with greater participation restrictions, and lower *VAPP Participation Restriction Scale* scores are associated with lesser participation restrictions.

The *VAPP PRS* analysis yielded different results compared to the *Total VAPP* and *VAPP ALS* analyses, as the between-subjects factor revealed no significant differences between Selectors and Non-Selectors (p=0.116). Further post-hoc evaluation of *Device condition* indicated that the 'Pre-device' condition (M=12.23, SD=5.56) was significantly higher than 'Device A' (M=5.34, SD=4.15, p=0.000); significantly higher than 'Device B' (M=7.22, SD=5.93, p=0.010); and significantly higher than 'Device C' (M=5.40, SD=3.08, p=0.001). Table 54 presents the descriptive statistics for the *VAPP PRS* scores obtained for the *Selector* and *Non-selector* groups in each device condition. Figure 32 presents the mean *VAPP PRS* results for the *Selector* and *Non-selector* groups in each of the device conditions.

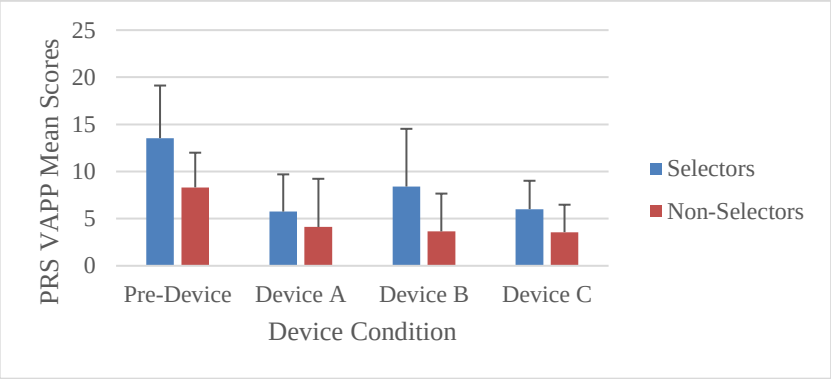
Table 54

Descriptive statistics for VAPP PRS obtained for the Selector and Non-selector groups relative to the device condition examined in the two-factor RM ANOVA analysis

Device Condition	N	Group	Mean (SD)
Pre-Device	12	Selectors	13.54 (5.58)
	4	Non-selectors	8.32 (3.68)
	16	Total	12.23 (5.56)
Device A	12	Selectors	5.75 (3.95)
	4	Non-selectors	4.12 (5.11)
	16	Total	5.34 (4.15)
Device B	12	Selectors	8.41 (6.12)
	4	Non-selectors	3.65 (4.01)
	16	Total	7.22 (5.93)
Device C	12	Selectors	6.01 (3.01)
	4	Non-selectors	3.57 (2.91)
	16	Total	5.40 (3.08)

Figure 32

VAPP PRS mean scores for Selector and Non-selector groups based on device condition Standard deviations are expressed by Error Bars



Two-factor RM MANOVA. A two-factor RM MANOVA was conducted to examine if there were differences between selector groups across device conditions. There was one within-subjects factor "*Device condition*" with four levels [Pre-Device, Device A, Device B, Device C] and one between-subjects factor "*Group*" with two levels [Selectors (Group 1), Non-Selectors (Group 2)]. The individual subscale categories on the VAPP served as the four dependent variables [C1VAPP, C3VAPP, C4VAPP, C5VAPP].

Results of the two-factor RM MANOVA for VAPP subscale categories, yielded significant results for the within-subjects factor "*Device condition"*, $F(12, 103)=2.464$, $p=0.007$, while the effect "*Device condition" x "Selectors"* condition factor, $F(12, 103)=0.656$, $p=0.789$ revealed non-significant results. When examining between-subjects factor (*Selectors vs Non-selectors),* no significant results were detected, $F(4, 11)=2.92$, $p=0.072$. Based on the significance of the within-subjects factor, *Device condition,* the univariate statistics of the four VAPP subscale categories were examined. The descriptive statistics are presented in Table 55 and the univariate statistics are presented in Table 56 for each of the four VAPP subscale categories. The detailed results of this two-factor repeated measures MANOVA analysis are presented in Appendix U.

Table 55

Descriptive statistics for VAPP categories between device conditions across Selector and Non-selector groups

VAPP Categories	Group	N	Mean	Std. Deviation	VAPP Categories	Group	N	Mean	Std. Deviation
C1 Pre-Device	Selectors	12	7.10	1.708	C4 Pre-Device	Selectors	12	23.19	8.544
	Non-selectors	4	3.35	2.120		Non-selectors	4	13.47	10.039
	Total	16	6.16	2.419		Total	16	20.76	9.621
C1 Device A	Selectors	12	3.54	1.896	C4 Device A	Selectors	12	14.04	8.321
	Non-selectors	4	2.20	2.225		Non-selectors	4	8.25	9.188
	Total	16	3.20	1.997		Total	16	12.59	8.623
C1 Device B	Selectors	12	4.24	2.578	C4 Device B	Selectors	12	15.11	9.687
	Non-selectors	4	2.57	2.444		Non-selectors	4	5.90	4.542
	Total	16	3.82	2.573		Total	16	12.81	9.483
C1 Device C	Selectors	12	4.21	1.880	C4 Device C	Selectors	12	12.71	5.974
	Non-selectors	4	1.75	1.634		Non-selectors	4	9.15	9.020
	Total	16	3.60	2.083		Total	16	11.82	6.707
C3 Pre-Device	Selectors	12	81.22	19.544	C5 Pre-Device	Selectors	12	47.03	14.311
	Non-selectors	4	53.65	17.370		Non-selectors	4	27.17	17.102
	Total	16	74.33	22.193		Total	16	42.06	16.957
C3 Device A	Selectors	12	44.00	16.988	C5 Device A	Selectors	12	30.64	18.130
	Non-selectors	4	23.15	23.950		Non-selectors	4	15.42	11.526
	Total	16	38.79	20.331		Total	16	26.83	17.718
C3 Device B	Selectors	12	46.50	25.624	C5 Device B	Selectors	12	34.53	17.627
	Non-selectors	4	22.25	23.271		Non-selectors	4	12.27	8.034
	Total	16	40.43	26.597		Total	16	28.96	18.435
C3 Device C	Selectors	12	43.11	14.762	C5 Device C	Selectors	12	24.82	11.741
	Non-selectors	4	26.72	17.807		Non-selectors	4	19.32	13.314
	Total	16	39.01	16.642		Total	16	23.45	11.941

Table 56

Effect of Device condition of two-factor RM MANOVA on VAPP categories for Selector and Non-selector groups

Device Condition **VAPP Categories**	***F*(3, 42)**	***p***	$\eta^2_{partial}$
C1	4.251	.010	.233
C3	12.059	.000	.463
C4	4.400	.009	.009
C5	4.864	.005	.005

***Device Condition*.** Based on the significant multivariate effect for the within-subjects factor "*Device condition"*, $F(12, 103)=2.464$, $p=0.007$, the univariate effects were analyzed for each of the four VAPP subscale categories. Based on this analysis, all VAPP subscale categories (C1, C3, C4, C5) were significant. A significant univariate main effect was found for VAPP subscale category 1: "*Self-perceived severity of speech problem*", $F(3, 42)=4.251$, $p=0.010$, $\eta^2_{partial} = 0.233$, VAPP subscale category 3: "*Effect on daily communication", F*$(3, 42)=12.051$, $p=0.000$, $\eta^2_{partial} = 0.463$, VAPP subscale category 4: "*Effect on social communication", F*$(3, 42)=4.400$, $p=0.009$, $\eta^2_{partial} = 0.009$, and VAPP subscale category 5 "*Effect on emotion", F*$(3, 42)=4.864$, $p=0.005$, $\eta^2_{partial} = 0.005$.

Post hoc comparisons (Device Condition). Post hoc comparisons were completed for the VAPP subscale categories with significant univariate main effects (VAPP subscale categories C1, C3, C4, C5) to determine the differences based on specific devices. The post hoc analyses using the LSD method, focused on the three pre-device conditions versus post-device conditions comparisons (i.e., pre-versus post-Device A, pre-versus post-Device B, and pre-versus post-Device C).

VAPP C1 (Device Condition). The post hoc comparison related to total *Device* VAPP subscale category 1: *Self-perceived severity of speech problem,* indicated that the 'pre-device condition' ($M=6.16$, SD=2.41) was significantly higher than 'Device A' ($M=3.20$, $SD=1.99$; $p=0.010$); 'Device B' ($M=3.82$, $SD=2.57$; $p=0.022$); and 'Device C' ($M=3.60$, $SD=2.08$; $p=0.001$). These results suggest all three devices produced ratings related to self-perceived voice severity that were less severe than the pre-device condition, suggesting a positive effect on perception of the severity of their voice after device trials.

VAPP C3 (Device Condition). The post hoc comparison related to total *Device* VAPP subscale category 3: *Effect on daily communication,* indicated that the 'pre-device' condition ($M=74.33$, SD=22.19) was significantly higher than 'Device A' ($M=38.79$, $SD=29.33$; $p=0.000$); 'Device B' ($M=40.43$, $SD=26.57$; $p=0.001$); and 'Device C' ($M=39.01$, $SD=16.66$; $p=0.000$). This result suggests all three devices produced ratings

related to effect on daily communication that were lower than the pre-device condition, suggesting a positive effect on daily communication following device use.

VAPP C4 (Device Condition). The post hoc comparison related to total *Device* VAPP subscale category 4: *Effect on social communication*, indicated that the 'pre-device condition' (M=20.76, SD=9.61) is significantly higher than 'Device A' (M=12.59, SD=8.62; p=0.027); 'Device B' (M=12.81, SD=9.43; p=0.020); and 'Device C' (M=11.82, SD=6.70; p=0.012). This result suggests all three devices produced ratings related to the effect on social communication that were lower than the pre-device condition, suggesting that device use was associated with a positive effect on self-rated social communication.

VAPP C5 (Device Condition). The post hoc comparison related to total *Device* VAPP subscale category 5: *Effect on emotion,* indicated that the 'pre-device condition' (M=42.06, SD=16.95) is significantly higher than 'Device A' (M=26.83, SD=17.71; p=0.005); 'Device B' (M=28.96, SD=18.43; p=0.036); and 'Device C' (M=23.45, SD=11.94; p=0.004). This result suggests all three devices produced ratings related to the effect on emotion that were lower than the pre-device condition, suggesting a positive effect of device use on ratings of emotion.

Selectors. Based on the significant multivariate effect for the within-subjects factor, the between-group factor (*Selectors* vs *Non-Selectors*) was examined. There was no significant multivariate result reached, $F(4, 11)=2.92$, p=0.072. As a result, the univariate effects related to the between-subjects factor (*Selectors vs Non-selectors*) was examined further across each of the VAPP subscale categories with the comparison alpha adjusted for each of the subsequent univariate analyses (i.e., $\alpha/4 = 0.0125$). The univariate results of '*Selectors'* are presented in Table 57.

Table 57

Effect of Selectors of two-factor RM MANOVA on VAPP categories

Selectors **VAPP Categories**	***F*(1, 14)**	****p***	$\eta^2_{partial}$
C1	9.290	.009	.399
C3	7.783	.014	.357
C4	3.744	.073	.211
C5	5.527	.034	.283

*Note: *adjusted alpha = 0.0125*

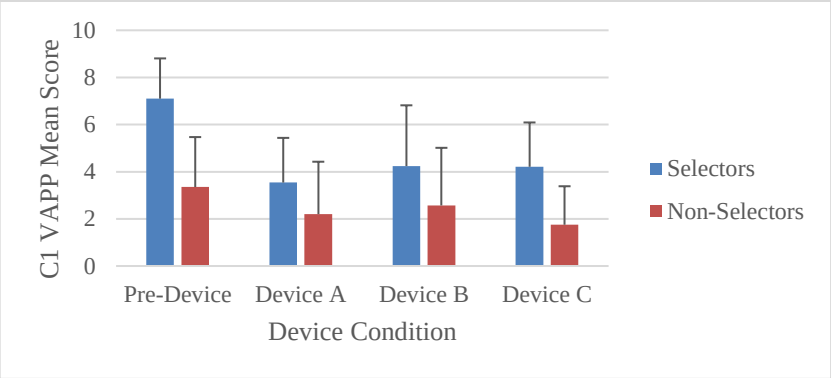
Table 57 demonstrates there were no significant univariate main effects detected for subscales C3, C4 or C5. However, a significant univariate main effect was found for subscale Category 1: "*Self-perceived severity of voice problem"*, $F(1, 14)=9.290$, $p=0.009$, $\eta^2_{partial} = 0.399$.

Post hoc comparisons (Selectors). Post hoc comparisons using the LSD method, were completed for the VAPP subscale categories with significant univariate main effects (VAPP subscales: C1) to determine the differences based on specific devices. The post hoc analyses focused on the comparisons between the two groups (*Selectors* versus *Non-selectors*).

The post hoc comparison for VAPP subscale category 1: "*Self-perceived severity of the voice problem*" indicated that the *Selector* group had a significantly ($p=0.009$) higher score ($M=4.77$, $SD=0.37$) than the *Non-selector* group ($M=2.46$, $SD=0.65$). Figure 33 represents the mean VAPP C1 results for the *Selector* and *Non-selector* groups in each of the device conditions. The results will be expanded upon in the next chapter.

Figure 33

C1VAPP mean scores for Selector and Non-selector groups based on device condition Standard deviations are expressed by Error Bars



Univariate Interaction analysis for Device Condition x Selector Groups. Based on the significant multivariate effect for the within-subjects factor, the interaction of "*Device condition*" x "*Selectors*" revealed non-significant results ($F(12, 103)=0.656$, $p=0.789$). The univariate results for the interaction involving the "*Device condition*" x "*Selector groups*" are presented in Table 58.

Table 58

Effect of Device x Selectors of two-factor RM MANOVA based on VAPP subscale categories

***Device x Selectors* VAPP Categories**	***F*(3, 42)**	***p***	$\eta^2_{partial}$
C1	1.022	.393	.068
C3	0.251	.860	.018
C4	0.667	.571	.045
C5	1.303	.286	.085

The univariate "*Device condition x Selector Groups*" interactions did not reach significance ($F(12, 103)=0.656$, $p=0.789$) for VAPP categories 1, 3, 4 and 5. When analyzing the results for the subscale category specific questions from the VAPP, the univariate statistics showed significant interactions for *Device condition* only and *Selectors* only. When reviewing the interactions between the device condition and the selector groups, none reached significance.

3.7.3 Objective 5C: Psychosocial Impact on Assistive Devices.

Three separate two-factor RM MANOVAs were conducted to determine differences between HP participants (*Selectors* vs *Non-selectors*) across device conditions based on PIADS subscale scores. Based on this objective, comparisons examined whether PIADS *Competence, Adaptability,* and *Self-esteem* subscale scores differed within device conditions across selector groups.

RM MANOVAs. The first RM MANOVA was based on the *PIADS Competence* subscale score, the second RM MANOVA was based on *PIADS Adaptability* subscale score, and the third RM MANOVA on *PIADS Self-Esteem* subscale score. For all three analyses, there was one within-group factor "*Device*" with three levels [Device A, Device B, Device C] and one between-group factor "*Group*" with two levels [Selectors (Group 1), Non-Selectors (Group 2)].

For the first analysis, the dependent variable was the "*PIADS Competence*" subscale score, for the second analysis, the dependent variable was the "*PIADS Adaptability*" subscale score, and the third analysis, the dependent variable was the "*PIADS Self-Esteem"* subscale score.

PIADS Competence subscale. The first analysis which was based on *PIADS Competence* subscale score did not reveal a statistically significant result for the within-subjects factor "*Device condition*", $F(2, 28)=1.124$, $p=0.339$. The within-subjects interaction "*Device condition" x "Selectors*" also revealed non-significant results, $F(2, 28)=1.088$, $p=0.351$. This non-significant interaction suggests that the pattern of differences was similar across the *Selector* and *Non-Selector* groups for the *PIADS Competence* subscale scores. When examining the between-subjects factor (*Selectors vs Non-Selectors*), no significant results emerged, $F(1, 14)=0.025$, $p=0.877$. These results suggest the *PIADS Competence* scores are not different across the three device conditions, or selector groups.

Further post-hoc evaluation of the non-significant results of *Device condition* indicated that there were no significant differences found between 'Device A' ($M=0.70$, $SD=0.48$)

and ‘Device B’ (*M*=0.55, *SD*=0.5), *p*=0.290; ‘Device A’ (*M*=0.70, *SD*=0.48;) and ‘Device C’ (*M*=0.86, *SD*=0.92), *p*=0.183; and ‘Device B’ (*M*=0.55, *SD*=0.51) and ‘Device C’ (*M*=0.86, *SD*=0.92), *p*=0.569. Table 59 presents the descriptive statistics for the *PIADS competence* subscale scores obtained for the *Selector* and *Non-selector* groups in each device condition. Figure 34 presents the mean *PIADS Competence* results for the *Selector* and *Non-Selector* groups in each of the device conditions.

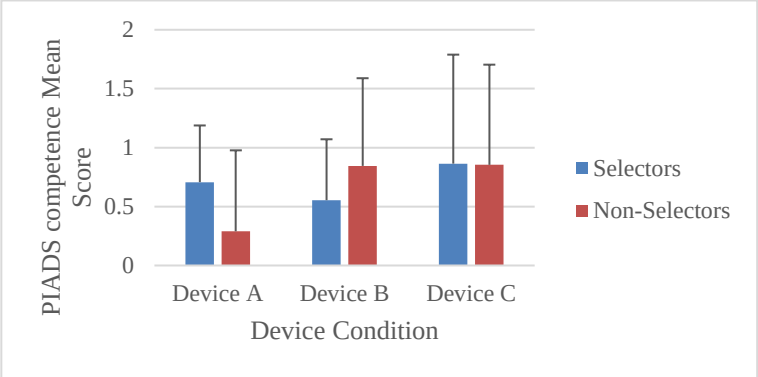
Table 59

Descriptive statistics for the PIADS Competence subscale score obtained for the Selector and Non-selector groups relative to the device condition examined in the two factor RM ANOVA analysis

Device Condition	Group	N	Mean (SD)
Device A	Selectors	12	.707 (.48)
	Non-selectors	4	.290 (.68)
	Total	16	.602 (.54)
Device B	Selectors	12	.554 (.51)
	Non-selectors	4	.845 (.74)
	Total	16	.627 (.56)
Device C	Selectors	12	.864 (.92)
	Non-selectors	4	.854 (.85)
	Total	16	.861 (.87)

Figure 34

Mean scores of PIADS competence for the Selector and Non-selector groups based on device condition
Standard deviations are expressed as Error Bars



PIADS Adaptability subscale. It is important to note that the Greenhouse Geisser correction was used to adjust for the lack of sphericity for this analysis, This analysis which was based on *PIADS Adaptability* subscale scores did not reach significance for “*Device condition*”, *F*(2, 28)=0.467, *p*=0.568. The within-subjects interaction “*Device*

condition" x "*Selectors*" also indicated a non-significant result, $F(2, 28)=2.470$, $p=0.123$. This non-significant interaction result suggests that the pattern of differences was similar across the *Selector* and *Non-selector* groups for the *PIADS Adaptability* subscale. When examining the between-subjects factor (*Selectors vs Non-selectors*), no significant differences were found, $F(1, 14)=0.002$, $p=0.964$. These results suggest the *PIADS Adaptability* scores are not different across the three device conditions or selector groups.

Further post-hoc evaluation of the non-significant results of the *Device condition* indicated that there were no significant differences found between 'Device A'($M=0.83$, $SD=0.70$) and 'Device B' ($M=0.55$, $SD=0.69$), $p=0.284$; 'Device A'($M=0.83$, $SD=0.70$) and 'Device C' ($M=0.95$, $SD=0.74$), $p=0.433$; and 'Device B' ($M=0.55$; $SD=0.69$) and 'Device C' ($M=0.95$, $SD=0.74$), $p=0.815$. Table 60 presents the descriptive statistics for the *PIADS Adaptability* subscale scores obtained for the *Selector* and *Non-selector* groups in each device condition. Figure 35 presents the mean *PIADS Adaptability* results for the *Selector* and *Non-Selector* groups in each of the device conditions.

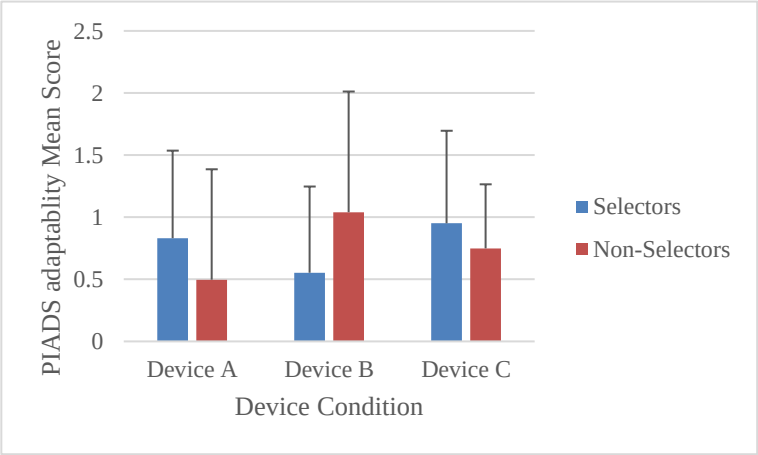
Table 60

Descriptive statistics for the PIADS Adaptability subscale score obtained for the Selector and Non-selector groups relative to the device condition examined in the two factor RM ANOVA analysis

Device Condition	Group	N	Mean (SD)
Device A	Selectors	12	.831 (.70)
	Non-selectors	4	.497 (.88)
	Total	16	.747 (.73)
Device B	Selectors	12	.553 (.69)
	Non-selectors	4	1.04 (.97)
	Total	16	.675 (.76)
Device C	Selectors	12	.951 (.74)
	Non-selectors	4	.749 (.51)
	Total	16	.900 (.68)

Figure 35

Mean scores of PIADS Adaptability for the Selector and Non-selector groups based on device condition
Standard deviations are expressed as Error Bars



PIADS Self-Esteem subscale. The third analysis which was based on *PIADS Self-Esteem* subscale score did not reveal a statistically significant result for the within-subjects factor "*Device condition*", $F(2, 28)=0.532$, $p=0.593$. The within-subjects interaction "*Device condition*" x "*Selectors*" also revealed non-significant results, $F(2, 28)=0.582$, $p=0.565$. This non-significant interaction suggests that the pattern of differences was similar across the *Selector* and *Non-selector* groups for the *PIADS Self-Esteem* subscale scores. When examining the between-subjects factor (*Selectors vs Non-selectors*), no significant results emerged, $F(1, 14)=0.734$, $p=0.406$. These results suggest the *PIADS Self-Esteem* scores are not different across the three device conditions or selector groups.

Further post-hoc evaluation of the non-significant results of the *Device condition* indicated that there were no significance differences found between 'Device A' ($M=0.61$, $SD=0.82$) and 'Device B' ($M=0.48$, $SD=0.69$), $p=0.586$; 'Device A' ($M=0.61$, $SD=0.82$) and 'Device C' ($M=0.74$, $SD=0.86$), $p=0.399$; and 'Device B' ($M=0.48$; $SD=0.69$) and 'Device C' ($M=0.74$, $SD=0.86$), $p=0.547$. Table 61 presents the descriptive statistics for the *PIADS Self-Esteem* subscale scores obtained for the *Selector* and *Non-selector* groups in each device condition. Figure 36 presents the mean *PIADS Self-Esteem* results for the *Selector* and *Non-Selector* groups in each of the device conditions.

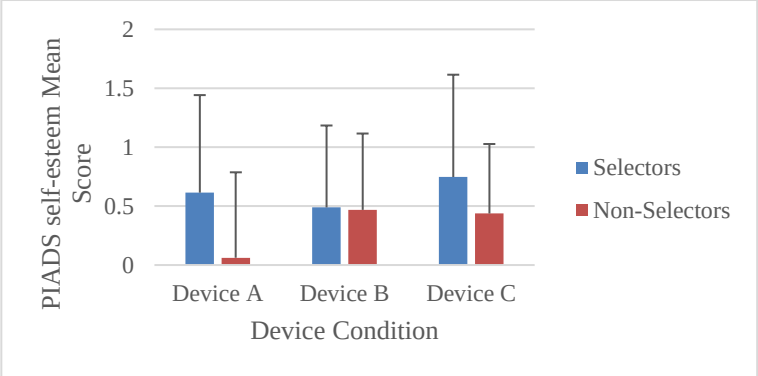
Table 61

Descriptive statistics for the PIADS Self-esteem subscale score obtained for the Selector and Non-selector groups relative to the device condition examined in the two factor RM ANOVA analysis

Device Condition	Group	N	Mean (SD)
Device A	Selectors	12	.614 (.82)
	Non-selectors	4	.062 (.72)
	Total	16	.476 (.81)
Device B	Selectors	12	.489 (.69)
	Non-selectors	4	.468 (.64)
	Total	16	.484 (.66)
Device C	Selectors	12	.747 (.86)
	Non-selectors	4	.437 (.59)
	Total	16	.669 (.80)

Figure 36

Mean scores of PIADS Self-esteem for the Selector and Non-selector groups based on device condition
Standard deviations are expressed as Error Bars



Overall, the results of this objective indicate that the PIADS subscale scores for competence, adaptability, and self-esteem were not statistically different across device conditions or between selector groups.

Chapter 4

4 Discussion

4.1 Overview

This study evaluated how individuals with hypophonia, and their primary communication partners rated communicative participation before and after experience with a speech amplification device. This study also evaluated ratings of communicative participation across three different amplification devices following trial periods outside of the laboratory.

The following sections in this chapter will discuss the primary findings of the present study and relate these findings to those of previous research. Subsequent sections will discuss the limitations of this study, followed by recommendations for future research. Lastly, clinical and research implications will be discussed.

The overarching goal of this study was to extend the research by Knowles and colleagues (2020) by providing recommendations for the use of amplification devices in this population from the perspective of patient-reported communicative participation. In order to examine patient reported communicative participation, the CES (Donovan et al., 2007), the VAPP (Ma & Yiu, 2001), and the PIADS (Day & Jutai, 1996) served as the primary measures of communicative effectiveness, voice activity and participation, and psychosocial impact of device use, respectively.

4.2 Objective 1: To evaluate if ratings of communicative participation differ across pre- versus post-device use

The first objective of the study investigated ratings of communicative participation before and after device trials. The aim of this objective was to determine if there were any differences in self-rated communicative effectiveness and ratings of voice activity and participation among HP participants before device use and after device trials.

Communicative Effectiveness. The CES evaluated self-rated communicative effectiveness before device use and after each device trial for each HP participant. Total and Mean CES scores were examined. Significant results were found between pre- and post-device use for Total CES and Mean CES scores demonstrating that participants with hypophonia rated themselves as less effective communicators in the pre-device condition and more effective communicators after trialing all three devices. Closer examination of these results found that the Total CES score for the pre-device condition was not significant for Device A, but the pre-device condition was significantly lower in comparison to Device B and Device C. Mean CES scores also revealed the same pattern of results with the pre-device score not being significantly different than Device A. In addition, similar to the Total CES score, Device B and Device C were rated as significantly higher than the pre-device condition. These results indicate that in comparison to using no speech amplification device, communicative effectiveness was rated higher following trials with Device B and Device C, but not Device A.

Finally, the individual CES items were analyzed to determine if there were specific CES items contributing to the observed differences between pre- versus post device use. Based on this analysis, CES item 5: *Being part of a conversation in a noisy environment;* CES item 7: *Having a conversation while traveling in a car;* and CES item 8: *Having a conversation with someone at a distance* reached significance. These results suggest that participants with hypophonia self-rated less effective communication pre-device use while attempting to converse in noisy environments, while travelling in a car, and while talking with another individual at a distance in comparison to after trialing speech amplification devices. Upon closer inspection, participants with hypophonia rated themselves as more effective communicating in noise when trialing both Device B and Device C in comparison to the pre-device condition. When communicating while traveling in a vehicle, participants with hypophonia rated better communicative effectiveness when trialing Device A and Device C in comparison to the pre-device condition. Finally, participants with hypophonia rated themselves as more effective communicating at an increased interlocuter distance when trialing both Device B and Device C in comparison to the pre-device condition. These results indicate that these three items of the CES showed improvement in communicative effectiveness ratings after

using a device. Taken together, Device C appeared to consistently produce ratings that resulted in significant changes to communicative effectiveness based on CES items related to speaking in noise, speaking while traveling in a vehicle, and speaking at a distance. Overall, the results of this sub-objective suggest that self-rated communicative effectiveness improved for HP participants after trialing the two out of the three speech amplification devices, Device B: NadyWA120BT and Device C: Nady351VR.

Voice Activity and Participation. The VAPP evaluated voice activity and participation before device use and after each device trial for each HP participant. Total VAPP, VAPP ALS, and VAPP PRS scores were examined. In addition, four subscale categories on the VAPP were also analyzed. Significant results were found between pre- and post-device use for the Total VAPP score demonstrating that participants with hypophonia rated themselves as having reduced voice activity and participation pre-device use and reported increased voice activity and participation after trialing all three devices. Closer examination of these results found that the Total VAPP score for the pre-device condition was significantly higher in comparison to Device A, Device B and Device C. These results indicate that in comparison to using no speech amplification device, participants with hypophonia reported improved (better) voice activity and participation total scores following trials with all three devices.

Activity limitation scores (VAPP ALS) revealed similar results with the pre-device score being significantly higher than Device A, Device B and Device C. These results indicate that in comparison to using no speech amplification device, participants with hypophonia reported less activity limitations following trials with all three devices. Participation restriction scores (VAPP PRS) also revealed similar results with the pre-device score being significantly higher than Device A, Device B, and Device C. These results indicated that in comparison to using no speech amplification device, participants with hypophonia reported less participation restrictions following trials with all three devices.

Finally, the four individual subscale categories of the VAPP were analyzed to determine if there were specific VAPP categories contributing to the observed differences between pre-versus post-device use. Based on this analysis, the examination of the four subscale

categories of the VAPP indicated that all categories reached significance. More specifically, for VAPP Category 1: *self-perceived severity of voice problem*, participants with hypophonia reported improved (better) ratings related to the severity of their voice problem after trialing all three devices in comparison to the pre-device condition. These results indicate that in comparison to using no speech amplification device, participants with hypophonia reported an improved or a better perception of their voice problem after trialing the three devices. For VAPP Category 3: *effect on daily communication,* participants with hypophonia rated improvements to daily communication when trialing all three devices in comparison to the pre-device condition. These results suggest that in comparison to not using a speech amplification device, participants with hypophonia reported an improvement to their daily communication after trialing any of the three amplification devices. For VAPP Category 4: *effect on social communication,* participants with hypophonia rated improved or better social communication when trialing all three devices in comparison to the pre-device condition. These results reveal that in comparison to not using a speech amplification device, participants with hypophonia reported an improvement to their social communication after trialing any of the three amplification devices. Finally, for Category 5: *effect on emotion*, participants with hypophonia rated improved or better effect on their emotion when trialing all three devices in comparison to the pre-device condition.

These results suggest that in comparison to using no speech amplification device, participants with hypophonia reported an improvement to their emotional state after trialing the three amplification devices. Overall, the results of this sub-objective suggest that in comparison to not using a speech amplification device, improvements were noted for all aspects of voice activity and participation, as measured using the VAPP, regardless of the speech amplification device trialed.

In general, ratings of communicative effectiveness and voice activity and participation were improved after trialing all speech amplification devices in comparison pre-device use. Despite the differences in constructs being measured, our results are consistent with those of Knowles and colleagues (2020), who found that in comparison to the no-device condition, all speech amplification devices tested were associated with gains in SNR and

in speech intelligibility. This result is likely capturing that our participants do indeed have significant reductions to their speech intensity that has negatively impacted not only acoustic (SNR) and perceptual (speech intelligibility) aspects of their speech production (i.e., Knowles et al. 2020), but their hypophonia is also negatively impacting their ability to communicate effectively and participate across different social contexts and environments. Our results, in concert with Knowles et al. (2020), also suggest that in a general way, amplification of the speech signal improves acoustic, perceptual, and participation-based aspects of communication, regardless of the device trialed. This finding is encouraging, since the prescription of a speech amplification device can immediately provide improvement to several aspects of communication as described above and solves the 'transfer of treatment' issue that is one of the most important concerns in the treatment of hypokinetic dysarthria (Rubow & Swift, 1985; see also; Gaballah et al., 2019, Adams & Dykstra, 2009).

A more detailed examination of results, however, do suggest differential effects of the three speech amplification devices, based on self-reported communicative effectiveness and voice activity and participation. Device B (NadyWA120BT) and Device C (Nady351VR) emerged as the two devices producing the highest ratings of communicative effectiveness in comparison to the pre-device condition. For the VAPP outcome measure, all devices were associated with improved voice activity and participation ratings. Recall that Device B, is similar to the BoomVox (see Andreetta et al. (2016) for description) in form and function, consists of a wireless headset microphone that transmits over a VHF channel to a large stationary speaker that can project amplified speech for several meters from the talker. Device C, on the other hand, is a body-worn, personal FM system typically used for individuals with hearing loss (Crandell, Charlton, Kinder, & Kreisman, 2001). A headset, microphone (Nady HM20) is worn by the talker and transmits the speech wirelessly to a pocket-sized VHF receiver, which is then amplified through headphones worn by the listener. Typically, when an FM system is used by a person with a hearing impairment, the individual with the hearing loss wears the headset and the talker wears the microphone. In both the current study and the Knowles study, the participants with hypophonia wore the microphone and the

communication partners wore the headset. This particular application of an FM system is considered to be a novel approach for the treatment of hypophonia.

Based on the CES, participants with hypophonia self-rated less effective communication pre-device while communicating in noise, communicating while traveling in a vehicle, and communicating with someone at a distance, in comparison to using a speech amplification device. These three communicative contexts have also shown to be significantly impacted in hypophonia in PD. It has been documented previously that speaking in noisy environments (including vehicles) and with increased interlocutor distances pose as acoustically challenging environments for individuals with hypophonia (Dykstra et al., 2015). Of note, Device C was rated consistently by our participants with hypophonia as producing improvements across these three contexts/environments as compared to not using an amplification device use. This amplification approach may be especially beneficial in these specific contexts (i.e., while communicating in noisy environments, while traveling in a vehicle, and over a distance) because of increased SNR. The signal level and signal-to-noise benefits of a FM system are typically in the range of 15 to 20 dB (Hawkins, 1984). When a FM microphone is located 6-8 inches from the speaker's mouth, the overall level of speech intensity is approximately 80-85 dB SPL (Cornelisse, Gagne & Seewald, 1991; Hawkins, 1984; Lewis, 1991; Lewis, Feigin, Karasek & Stelmachoqicz, 1991). Using a personal FM system would also allow the quality of the acoustic signal to be maintained even with increased interlocuter distances between communicative dyads. The approximate operating range for this device is up to 250 feet, depending on the site conditions (Nady351VR User Manual). In addition, there has been reported additional benefits of increased attention span, reduced distractibility and increased sound awareness when using this device (Blake et al., 1991; Casterline, Flexer & DePompei, 1989; Flexer, 1989; Stach, Loiselle & Jerger, 1987).

In comparison to the other devices that use a portable speaker (i.e., Device A: Chattervox, and Device B: NadyWA120BT), using a portable FM system as a method of amplification allows the acoustic signal to be concentrated and delivered directly to the ear of the listener with less competition from background noise (e.g., in a noisy environment or the noise associated while travelling in a car). Knowles and colleagues

(2020) determined that the introduction of background noise resulted in lower intelligibility scores for all device conditions except for Device C. Knowles et al. (2020) determined that SNR levels were greatest for Device C in noise conditions followed by Device B and then Device A. In addition to Device C outperforming Devices A and B for both SNR and speech intelligibility, it was found that the intelligibility benefit was most noticeable in adverse listening conditions for naïve listeners (Knowles et al., 2020). Similar to that of Knowles et al., (2020), the current study also demonstrates that in relation to the pre-device condition, Device C was rated by our participants with hypophonia as providing the most improved communicative effectiveness ratings in adverse communicative listening conditions such as in noise and with increased interlocuter distance.

4.3 Objective 2: To evaluate if there are differences in self-rated communicative participation across the three devices.

The second objective of the study investigated ratings of communicative participation across the three amplification devices. The aim of this objective was to determine if there were any differences in ratings of communicative effectiveness, ratings of voice activity and participation, and ratings of psychosocial impact of device use across the three devices among the participants with hypophonia.

Communicative Effectiveness. The CES evaluated self-rated communicative effectiveness across each of the three device trials for each HP participants. Total and Mean CES scores were examined. There were no significant results found across device conditions for Total CES and Mean CES scores demonstrating that participants with hypophonia did not rate their communicative effectiveness significantly different across the three devices. Individual items on the CES were analyzed to determine if there were specific CES items that were significantly different across the three device conditions. Based on this analysis, CES item 4: *Conversing with a stranger over the telephone* and CES item 8: *Having a conversation with someone at a distance (across a room)* revealed differences across device conditions. More specifically, for CES item 4, participants with hypophonia rated themselves as significantly more effective communicating with a

stranger over the telephone when using Device B in comparison to Device C. There was no significance detected when comparing Device A to Device B, as well as no significance detected when comparing Device A to Device C. For CES item 8, participants with hypophonia rated communicative effectiveness related to conversing over a distance significantly higher when using Device B in comparison to Device A. As well, participants with hypophonia rated communicative effectiveness significantly higher when trialing Device C in comparison to Device A. There was no significant difference in ratings of communicative effectiveness related to conversing over a distance when comparing Device B to Device C.

Overall, the results of this sub-objective suggest that self-rated communicative effectiveness related to speaking to a stranger on the phone improved for HP participants after trialing Device B: NadyWA120BT and in relation to communicating over a distance, participants with hypophonia reported improved communicative effectiveness when trialing both Device B and Device C.

Voice Activity and Participation. The VAPP evaluated voice activity and participation across each of the three device trials for each HP participant. Total VAPP, VAPP ALS, and VAPP PRS scores were examined. In addition, four subscale categories on the VAPP were also analyzed. There were no significant results found across device conditions for *Total VAPP*, *VAPP ALS* and *VAPP PRS* scores demonstrating that participants with hypophonia did not rate their voice activity and participation significantly different across the three devices. Analysis of the four categories on the VAPP (Category 1: *Self- perceived severity of voice problem*; Category 3: *Effect on daily communication*; Category 4: *Effect on social communication*; Category 5: *Effect on emotion*) revealed no significant differences based on device condition for any of the VAPP categories. These results indicate that participants with hypophonia self-rated the perceived severity of their voice problem, the effect on their daily communication, the effect on their social communication, and the effect on their emotion similarly across the three devices they trialed. Overall, the results of this sub-objective suggest that self-rated voice activity and participation did not differ significantly amongst the voice amplification devices trialed.

Psychosocial Impact of Assistive Devices. The PIADS evaluated ratings of the psychosocial impact of each of the three speech amplification device trials for each HP participant. PIADS Competence, PIADS Adaptability, and PIADS Self-Esteem subscale scores were examined. There were no significant results found across device conditions for *PIADS Competence*, *PIADS Adaptability* and *PIADS Self-esteem* scores. These results suggest that the psychosocial impact of using an amplification device based on the parameters of self-rated competence, adaptability, and self-esteem were not rated significantly different by our participants with hypophonia across the three voice amplification devices trialed.

In general, overall ratings of communicative effectiveness, voice activity and participation, and psychosocial impact of using voice amplification devices did not reveal significant differences across the three device conditions. Device B (NadyWA120BT) did, however, produce ratings that resulted in significant changes to communicative effectiveness based on CES items related to speaking with a stranger over the telephone and speaking at a distance. Andreetta and colleagues (2016) reported that the BoomVox, which is similar to the NadyWA120BT in form and function, received generally good experience scores. The BoomVox significantly produced the highest intensity, SNR levels, and conversational speech intelligibility ratings, and was the highest recommended device in comparison to the eight devices trialed in Andreetta's study based on these outcome measures.

Knowles and colleagues (2020) reported that Device B (NadyWA120BT) outperformed Device A (Chattervox) in SNR, but these two devices did not differ significantly from one another in terms of how intelligible the speakers were, regardless of the amount of background noise. When exploring the devices chosen by participants in Knowles' study, participants reported that their reasons for choosing Device B included being able to leave the loudspeaker in a given location in their home (e.g., kitchen or living room), and some felt their communication improved and their speech was clearer when they heard their own amplified speech through the loudspeaker. Further, in the Knowles' study, those participants who chose Device B demonstrated overall lower SNR values and were less intelligible in adverse listening conditions in comparison to those participants that

did not choose Device B (Knowles et al., 2020). Although the loudspeaker component for the BoomVox and the NadyWA120BT (Device B) makes these devices larger, the FM technology component of the headset increases the device portability in the home environment.

Knowles and colleagues (2020) reported that greater SNR ratios were associated with Device C (Nady351VR) in both multi-talker noise conditions and no noise conditions. In addition, Device C was associated with higher intelligibility scores in comparison to Device A and Device B. Further, Knowles and colleagues reported that Device C was rated by participants with hypophonia as more preferable than Devices A and B. The preference for Device C (Nady351VR), the personal FM system, was reported by several participants with PD to be related to the discreteness of the device and greater amplification for the listener/communication partner in comparison to the other devices. The benefits of using a portable FM system as an amplification device for individuals with hypophonia deserves future study to delineate the specific contexts and environments that show the most benefit from the novel application of this communication system for individuals with hypophonia.

Previous studies have utilized the CES to study communicative effectiveness in individuals with PD (Donovan et al., 2008; Dykstra et al., 2015). Dykstra and colleagues (2015) studied the relationship between speech intensity and self-rated communicative effectiveness using the CES and found that "*Having a conversation with others at a distance*" accounted for approximately 61.5% variance between participants with PD and control participants. The Dykstra et al. (2015) study also demonstrated that individuals with PD and hypophonia self-reported difficulty communicating effectively across a variety of speaking situations such as having a conversation with a stranger over the telephone, conversing while traveling in a car, having a long conversation, speaking before a group, and speaking in a noisy environment (Dykstra et al., 2015).

In the current study, it should be noted that the significance of CES item 4: *Conversing with a stranger over the telephone* should be interpreted with caution due to potential methodological limitations. More specifically, if HP participants did not have the

opportunity to experience a specific communicative situation when trialing a device(s), they were instructed to extrapolate or 'think about' what their effectiveness would be like in a specific communicative situation based on their overall experience with the device throughout the trial week. Another potential limitation relates to the ability to use an amplification device, such as Device B, while using the telephone. Due to the configuration and set-up of the amplification device with that of a telephone, the pairing of these two devices would have been possible, but technically challenging, if the HP participant used the telephone receiver to listen and speak to the caller. However, this may have been possible if the HP participant elected to use the speaker phone option during a call and placed the device loudspeaker near the speaker phone. This issue of using a portable FM system (Device C) while using the telephone is also problematic due to the nature of the technology and device set-up (i.e., the listener/communication partner is required to wear a headset microphone to hear the amplified speech of the HP participant, which is not possible for a listener/caller on the telephone). This CES item related to telephone use will be discussed specifically as a limitation of this study, but also as a direction for future study.

The significant result based on CES item 8: *Having a conversation with someone at a distance (across a room)* revealed differences among the devices, with Device B and Device C producing higher ratings of communicative effectiveness as compared to Device A. Although several studies have demonstrated that participants with PD and hypophonia produce conversational speech intensity that is approximately 4 dB lower than control participants (Adams, Winnell & Jog, 2010; Ho et al., 1999a; Ho et a., 2000; Fox & Ramig, 1997; McCaig, Adams, Dykstra & Jog, 2016), many of these studies have also demonstrated that the same participants can significantly increase their speech intensity across interlocuter distances, thereby showing the same pattern of intensity regulation as control participants (Adams et al., 2010; Ho et al., 1999b; Ho et al., 2000 McCaig et al., 2016). This finding suggests a normal pattern of intensity regulation in PD in response to communicating across a distance, but with reduced gain. Interestingly, when communicative effectiveness is measured, participants with PD and hypophonia self-rated their effectiveness communicating over a distance as significantly impacted (Dykstra et al., 2015). A possible interpretation of these somewhat discrepant findings is

that although individuals with PD and hypophonia can increase their speech intensity when communicating across a distance, suggesting a normal pattern of intensity regulation, the amount of intensity gain produced may not be adequate to compensate for their overall reduced habitual speech intensity. This interpretation may help to explain the findings in the Dykstra study demonstrating reduced communicative effectiveness when communicating over a distance. It is possible that individuals with PD and hypophonia do not feel effective communicating over a distance because they are still not able to increase their speech intensity to a level where they are able to produce audible/intelligible speech to their communication partner(s) situated at a distance.

With respect to changes in SNR and speech intensity as the result of using an amplification device, our results align with those reported in the Andreetta et al. (2016) study. In the Andreetta study, the BoomVox, which is similar to our Device B (NadyWA120BT), demonstrated higher SNR and speech intensity ratings than the Chattervox (our Device A). In comparison to the other eight devices studied (including the Chattervox) in Andreetta's study, the BoomVox produced the highest SNR and speech intensity levels. In terms of speech intelligibility, Andreetta and colleagues (2016) reported that the average transcribed conversational intelligibility score for the BoomVox was significantly higher than two other devices in the study: the SoniVox and the ADDvox. In addition, the average VAS-based intelligibility listening task scores for the BoomVox was significantly higher than the Spokeman, the Oticon Amigo, the ADDvox, and the SoniVox. However, in Andreetta's study, the BoomVox did not produce the highest device preference ratings. For example, the BoomVox was rated second highest for power and sound quality, third for comfort and visual appearance, and fourth for overall preference by her participants with PD. These results provide an interesting example of potential discrepancy between speech performance-based measures and experience-based preference ratings in the evaluation of amplification devices (Andreetta et al., 2016).

Previous studies have used the VAPP to capture activity limitations and participation restrictions of individuals with several voice disorders such as dysphonia (Ma & Yiu, 2001), hyperfunctional phonation, vocal nodules, polyps, and chronic laryngitis

(Bermúdez-de-Alvear et al., 2019), vocal complaints (Ricarte, Oliveira & Behlau, 2013); and other functional and organic voice disorders (i.e., laryngeal pathologies, oropharyngeal cancers) (Sukanen et al., 2007). These studies have determined that the Voice Activity and Participation Profile is a valid and reliable instrument to measure voice related quality of life, intervention, and treatment gains for these clinical populations (Bermúdez-de-Alvear et al., 2019; Ma & Yiu, 2001; Ricarte, Oliveira & Behlau, 2013; Sukanen et al., 2007).

The Voice Activity and Participation Profile has also been used as an outcome measure in PD research. For example, Simberg and colleagues (2012) administered the VAPP to individuals with PD and hypokinetic dysarthria to evaluate the impact of a 15-day intensive speech treatment protocol. The results of this study showed that overall VAPP ratings significantly decreased from pre-treatment to six months post-treatment, suggesting an improvement in activity participation in their participants with PD. Simberg and colleagues (2012) concluded that patient-reported outcome measures provide valuable insight into the perspectives of individuals with communication disorders. Compared to the current study, however, our results did not produce significant differences in VAPP ratings across the three devices trialed. It should be noted that our HP participants did show an improvement in VAPP ratings after using any of the three amplification devices in comparison to the pre-device condition (see Objective 1). This result may suggest that the VAPP may not be sensitive to the potential nuanced changes to activity and participation experienced by our HP participants across the three device trials in this time frame. Our results, based on Objective 1 however, do align with the Simberg study in that an intervention (i.e., voice amplification) resulted in improved voice activity and participation in comparison to no intervention (i.e., pre-device condition).

Similar to the VAPP, the Psychosocial Impact of Assistive Devices Scale did not reveal significant differences across the three devices trialed based on ratings of competence, adaptability and self-esteem of using an assistive device. It is possible that this outcome measure was not sensitive to differences related to the psychosocial impact of using an amplification device as experienced by our HP participants when trialing each device.

Overall, when evaluating differences in self-rated communicative participation across the devices in the current study (Chattervox, NadyWA120BT, and Nady351VR), only CES items 4 and 8 revealed significant differences across the three devices trialed by our participants. CES Question 8 is the most interesting of the two significant CES items because it is a rating of effectiveness communicating across a distance. This is an important finding because communicating effectively with increased interlocuter distance has shown to be impaired in hypophonia (Dykstra et al., 2015). Finding a device effect (i.e., Device B and Device C producing higher ratings than Device A) is promising in our ability to prescribe with evidence specific speech amplification devices that will be effective in helping to improve this aspect of communication (i.e., communicating effectively over a distance). In general, however, there were no significant differences in outcome measures regarding overall communicative effectiveness, voice activity and participation, and the psychosocial impact of using assistive devices. These results suggest that communicative participation was not rated significantly different by our HP participants across the three amplification devices trialed. It is possible that these outcome measures are not sensitive enough to capture the nuanced differences in communicative participation experienced while participants trialed the three devices. Alternatively, it may be that our participants may have required more time trialing each device to experience the potential differential effects that each amplification device could have on communicative participation.

4.4 Objective 3: To determine if ratings of communicative participation differ for individuals with hypophonia versus their primary communication partners across device conditions.

The third objective of the study investigated differences of ratings of communicative participation between individuals with hypophonia and their primary communication partners across the three amplification devices. The aim of this objective was to determine if there were any differences in ratings of communicative effectiveness, ratings of voice activity and participation and ratings of psychosocial impact of device use between the participants with hypophonia and their communication partners.

Communicative Effectiveness. The CES evaluated self-rated communicative effectiveness between participant groups across each of the three devices trials. Total and Mean CES scores were examined. There were no significant results found between groups for Total CES or Mean CES. These findings demonstrate that the ratings made by the participants with hypophonia were not significantly different from the ratings made by their primary communication partners during the same device conditions. When comparing the individual items on the CES, 'device' condition reached significance while 'group' condition did not reach significance. Upon closer inspection, significant device condition univariate effects were found for CES questions 1, 2, 4, 5, 6, 7 and 8. Similar to the results obtained in Objective 1A, this finding demonstrates that the 'device' condition effect is most likely related to pre-device and post-device conditions for both the participants and their communication partners. Finally, both the HP participants and their primary communication partners demonstrated a similar pattern of CES ratings across the different devices trialed as evidenced by a non-significant interaction. Overall, the results of this sub-objective suggest that self-rated communicative effectiveness does not differ for the HP participants and their communication partners while trialing the three speech amplification devices studied.

Voice Activity and Participation. The VAPP evaluated voice activity and participation between participant groups across each of the three devices trials. Total VAPP, VAPP ALS and VAPP PRS scores were examined. In addition, four subscale categories on the VAPP were analyzed. There were no significant results found between groups for *Total VAPP*, *VAPP ALS* or *VAPP PRS*. These findings demonstrate that the ratings made by the participants with hypophonia were not significantly different from the ratings made by their primary communication partners. Similarly, there were no significant results found between the group interaction and the device conditions, suggesting self-rated voice activity and participation did not differ significantly between groups across the voice amplification devices trialed.

Upon closer inspection of the VAPP categories, 'device' condition was significant, however the 'group' condition did not reveal significant effects. Similar to the results obtained for Objective 1B, this finding also demonstrates that the 'device' condition

effect is most likely related to pre-device and post-device conditions for both the participants and their communication partners, indicating that the ratings of voice activity and participation were improved after trialing the three speech amplification devices in comparison to pre-device use. Further, both the HP participants and their primary communication partners demonstrated a similar pattern of VAPP ratings across the different devices trialed as evidenced by a non-significant interaction. Overall, the results of this sub-objective suggest that ratings obtained from the VAPP do not differ significantly between participants with hypophonia and their communication partners while trialing the three speech amplification devices studied.

Psychosocial Impact of Assistive Devices. The PIADS evaluated ratings of psychosocial impact between participant groups across each of the three devices trials. PIADS Competence, PIADS Adaptability, and PIADS Self-Esteem scores were examined. There were no significant differences detected between groups for *PIADS Competence*, *PIADS Adaptability* and *PIADS Self-esteem*. These results suggest that the psychosocial impact of using an amplification device based on the parameters of self-rated competence, adaptability, and self-esteem is rated similarly by participants with hypophonia and their primary communication partners across each of the three amplification devices trialed.

In general, overall ratings of communicative effectiveness, voice activity and participation, and the psychosocial impact of using voice amplification devices did not reveal significant differences between participants with hypophonia and their primary communication partners across the three device conditions. These finding demonstrate that primary communication partners rate communicative participation similarly to their partners with hypophonia, suggesting that the primary communication partners can appraise communicative participation similarly to the self-ratings made by their partners with hypophonia.

Exploring the agreement between patient and proxy ratings has been studied in the PD literature with variable results. Several studies (Dykstra et al., 2015; Martinez-Martin et al., 2004; McRae et al., 2002; Parveen and Goberman, 2017; Sebring et al., 2018) have

demonstrated similarities in ratings between individuals with PD and their primary communication partners. For example, McRae and colleagues (2002) found a high level of agreement between individuals with Parkinson's disease and their caregivers on responses to the Schwab and England Activities of Daily Living Scale, which estimates the daily abilities of individuals living independently with Parkinson's disease. Further, Martinez-Martin and colleagues (2004) also found concordance in dyad responses, but the ratings that pertained to more objective variables such as functional status had higher concordance than the subjective variables studied such as health-related QoL in their PD-proxy dyads. Parveen and Goberman (2017) examined proxy and self-ratings of individuals with PD using the Vocal Handicap Index (VHI; Jacobson, 1997) and the Parkinson's Disease Questionnaire - 39 (PDQ-39; Jenkinson et al., 1997). The results of this study found a good level of agreement between self and proxy ratings on both the VHI and PDQ-39 mobility, suggesting that individuals with PD and their communication partners can similarly rate speech and motor-related changes associated with Parkinson's disease (Parveen and Goberman, 2017). Finally, Dykstra and colleagues (2015) studied participants with PD and hypophonia and their PCPs using the CES and found that communicative dyads rated communicative effectiveness similarly. Proxy ratings have also been examined in other motor speech disorders that support the findings of Dykstra et al. (2015). McAuliffe and colleagues (2017) and Ball and colleagues (2004) studied proxy ratings of communicative effectiveness in TBI and ALS, respectively. Both studies found no significant differences in ratings made by participants and their primary communication partners on the CETI.

On the contrary, there have been studies that have found differences in ratings between participants with PD and their primary communication partners (Donovan et al., 2008; Sebring et al., 2018; Morrow et al., 2015). Donovan et al. (2008) found a statistically significant difference between CES ratings made by individuals with PD and their communication partners. Specifically, Donovan and colleagues found that individuals with PD self-rated communicative effectiveness higher as compared to ratings made by their communication partners. Donovan interpreted this finding as a potential indication that individuals with Parkinson's disease may lack insight into their deficits, suggesting a sensorimotor deficit contributing to a mismatch between their actual performance and

their judgment of their performance (Abbruzzese & Berardelli, 2003; Ho et al., 2000). Sebring et al. (2018) explored the validity of proxy caregiver reports for several palliative care outcome measures for individuals with Parkinson's disease and found that caregivers rated symptom severity higher than the patients and these group differences were most pronounced in patients with advanced illness (Sebring et al., 2018). Finally, Morrow et al. (2015) investigated whether patient-spouse co-reporting resulted in similar ratings of health-related quality of life (HRQoL). The researchers found patient ratings of physical HRQoL was higher than ratings made by their spouses. It was suggested that spouses have different perspectives of their partner's (i.e., the patient) physical quality of life and that proxy ratings should be treated with caution (Martinez-Martin et al. 2004; Morrow et al., 2015).

Examining communicative participation from both the perspective of the individual with hypophonia and their primary communication partner is important because it allows us to determine if differences exist in the perception of communicative participation between a communicative dyad. Gathering information from a dyad can be of clinical value for several reasons. The first reason relates to the perceptions or ratings between communicative dyads, especially when perceptions are not in agreement. This information can allow the SLP to facilitate a discussion with the dyad regarding the reasons for the observed discrepancies and then can provide strategies to overcome communication breakdown between partners (Dykstra, 2015). Secondly, ratings made by both the patient and their primary communication partner is beneficial because this information may provide the clinician with an opportunity to establish treatment goals that are mutually agreed upon by both parties and to begin providing information and training to the communicative dyad early on in treatment (Donovan et al., 2008). Finally, the third reason relates to the reliability of primary communication partners to serve as proxies. Although it is preferable to have the individual with the communication disorder provide self-ratings or self-report, there may be situations or contexts in which the communication partner needs to step in to provide ratings or perspective on their partner's behalf, such as in times of illness. The results of our study provide support for the reliability of proxy ratings related to the construct of communicative participation in PD.

4.5 Objective 4: To determine if a device hierarchy exists based on patient reported outcome measures related to communicative participation, and if this potential device hierarchy maps onto the device hierarchies proposed by Knowles et al. (2020) based on variables related to device preference, and performance-based objective speech measures of SNR and speech intelligibility.

The fourth objective of the study investigated device hierarches based on each of the communicative participation outcome measures. The aim of this objective was to determine if a device hierarchy existed based on participation-based outcome measures and if these potential device hierarchies mapped onto the device hierarchies proposed by Knowles et al., (2020).

Device Hierarchies based on Communicative Participation-based Outcome Measures. In the current study, a variety of device hierarchies emerged based on the three participation-based outcome measures studied. Although there were some differences in specific hierarchies within and across the three outcome measures, there were trends and patterns that emerged suggesting that the participants with hypophonia placed Device C (Nady 351VR) first in the device hierarchy, followed by Device B (Nady WA120BT) based on participation-based outcome measures. Device A (Chattervox) did place first in the hierarchy for some VAPP-related items, but overall, Device C and B consistently emerged in first or second position.

Based on the CES, Device B and Device C consistently produced the highest overall ratings for communicative effectiveness. Device B emerged first in the device hierarchy for Total and Mean CES scores, as well as for CES items related to speaking with familiar people and strangers on the telephone, speaking with strangers in a quiet environment, speaking in noise in a social gathering, and speaking over a distance. A potential interpretation of these results is based on the design and style of the devices. Since Device B uses a stationary loudspeaker, this style of device has the ability to be used when using the telephone. This can occur if the speaker phone option is used so the stationary speaker of the amplification device can be placed near the telephone

receiver/speaker. As discussed previously, pairing Device C, the personal FM amplification system, with a telephone would be technically challenging, therefore it is not entirely surprising that this device was not rated first for the CES items related to telephone use. Similarly, Device B was rated highest for speaking in a noisy social gathering and speaking over a distance. The more powerful 20W stationary speaker associated with Device B could allow for conversational partners to more effectively communicate with the speaker with hypophonia in noise and at a distance relative to the less powerful Device A, a 5W device. Conversely, Device C is intended to be used with a single conversational partner. This style of device would, therefore, not be as effective in a more social setting with multiple communication partners. Device C emerged first in the hierarchy for CES items related to having a conversation with a friends or family at home, speaking to friends or family when emotionally upset or angry, and having a conversation while traveling in a car. A potential interpretation of these results can be discussed in relation to the design and style of the device. Device C, the personal FM amplification system, is intended to be used with a single communication partner. The social contexts related to conversing with a friend or family member at home and when emotionally upset or angry are typically more intimate conversational situations. These types of dyadic communication contexts could be best served by an amplification device that is intended to be used with a single communication partner. Similarly, the preference for Device C while traveling in a car could also relate to the design of Device C. Since Device C is a portable amplification system it would not require the user to have transport a relatively large portable loudspeaker into a vehicle.

Based on the VAPP, Device C and Device A consistently produced the highest overall ratings for voice activity and participation scores. Device C emerged first in the device hierarchy for the Total VAPP score, as well as items related to social communication and effect on emotion. Device A on the other hand, was rated first for the Activity Limitation Score, the Participation Restriction Score, and items related to self-perceived voice severity and effect on daily communication. Similar to the CES, a potential interpretation of these results can be discussed in relation to the style and design of these two amplification devices. It is possible that the discreteness of Device C has favourable impacts on overall voice activity and participation, social communication, as well as a

positive impact on emotion. It is interesting to consider the possibility that if the individual with hypophonia can feel as if they can participate more effectively while using a discrete style of amplification device, there may be a positive effect on emotion. It may be that this style of device does not draw more attention to their communication disorder. Similarly, with Device A being a portable wired belt-pack speech amplifier, this style of device may also afford similar benefits to voice activity and participation due to its portability, especially in comparison to Device B which uses a stationary loudspeaker for voice amplification.

Based on the Psychosocial Impact of Assistive Devices Scale (PIADS), Device C consistently emerged first across all PIADS subscale domains. This result suggests that a portable FM speech amplification system may provide the speaker with hypophonia improved competence, adaptability, and self-esteem when using this style of amplification device. A possible interpretation of this result could be due to both the discreteness and portability that this style of device affords.

Comparison of device hierarchies across studies. Based on the primary study, Knowles and colleagues determined that the device hierarchy for the objective speech outcome measures of SNR and speech intelligibility was: Device C > Device B ≥ Device A > No Device, whereas, for overall device selection the hierarchy that emerged was: Device A > Device B & Device C. These hierarchies suggest Device C was rated the highest for objective speech measures (i.e., SNR, speech intelligibility), while Device A was rated and selected as the most preferred device by our participants with hypophonia.

Speech intelligibility and Signal to Noise Ratio. When comparing Knowles' device hierarchy for speech intelligibility and SNR (Device C > Device B ≥ Device A > No Device) to our device hierarchies based on participation-based outcome measures, there were only two CES items (Q1: *Having a conversation with a family member or friends at home*, Q6: *Speaking to a friend when you are emotionally upset or you are angry*) and two PIADS subscales (*competence*, *self-esteem*) that mapped directly onto Knowles' hierarchy. If we look more specifically at Device C because of its first-place rank in Knowles' hierarchy, additional participation-based outcome measures align with

speech intelligibility and SNR. CES question 7 (*communicating while traveling in a car*), along with the remaining PIADS subscale related to adaptability, the Total VAPP score, and VAPP subscales related to social communication and effect on emotion were also associated with Device C being rated as first in the hierarchy. It may be that a portable FM speech amplification system may provide the speaker with hypophonia improved competence, adaptability, and self-esteem when using this style of amplification device. The portable FM system also appears to provide better participation-based outcomes related to traveling in a car, when speaking to a friend or family member at home, when communicating when emotionally upset or angry, and has a positive effect on overall voice activity and participation outcomes, including a positive effect on social communication and emotion. A possible interpretation of this result is that Device C provides increased speech intelligibility and SNR in communicative situations/environments that are more dyadic in nature (versus communicative situations/environments with multiple communication partners). These participation-based outcomes may be rated as higher when using Device C because of the additional benefits of being discrete and portable.

Overall Device Selection. Interestingly, Knowles and colleagues' hierarchy for *overall device selection* (Device A > Device B & Device C) did not map onto their hierarchy for the objective speech measures of speech intelligibility and SNR. Similarly, Knowles' hierarchy based on *overall device selection* did not map directly on to our device hierarchies across any of our patient-reported communicative participation outcome measures.

Andreetta et al. (2016) and Knowles et al. (2020) have suggested that user preference and user comfort do not necessarily predict device performance or effectiveness. For example, Andreetta and colleagues found that the Spokeman, a small, lightweight amplification device, received the highest ratings for dimensions of physical comfort, visual presentation, and overall preference, despite the finding that it performed more poorly compared to other devices on based on SNR and intelligibility (Andreetta et al., 2016, Knowles et al., 2020). Both authors cautioned that SLPs working with these individuals should explore devices that optimize performance without compromising a

client's aesthetic preferences. Knowles and colleagues reported that during informal discussions with the study participants regarding device preference, participants reported that they would be disinclined to use a device they found to be too unsightly or uncomfortable. Therefore, it is important to consider these additional factors that may impact user buy-in and the likelihood of sustained use.

4.6 Objective 5: To determine if final device selection is associated with patient-reported outcome data obtained in the three device trial periods.

The fifth objective of the study explored if HP participants selected a specific speech amplification device based on self-rated communicative effectiveness scores, voice activity and participation scores, and psychosocial impact scores during the device trial periods. This objective also explored differences in the ratings made by the participants that chose to select and purchase a device (*Selector* group, *N*=12) versus the participants who chose not to select or purchase a device (*Non-Selector* group, *N*=5), based on the three patient-reported outcome measures. In the primary study conducted by Knowles et al. (2020), seven participants chose Device A (HP03, HP06, HP16, HP17, HP19, HP21, HP22), two participants chose Device B (HP04, HP18), three participants chose Device C (HP01, HP02, HP14), and five participants declined to take a device (HP07, HP08, HP11, HP12, HP13).

Communicative Effectiveness. The CES evaluated self-rated communicative effectiveness between the *Selector* and *Non-Selector* groups across each of the three devices trials. Total and Mean CES scores were examined. Significant results were found between the *Selector* and *Non-Selector* groups for Total CES and Mean CES demonstrating that the *Selector* group had significantly lower Total and Mean CES scores than the *Non-Selector* group across the device conditions. When the individual CES questions were analyzed individually, overall, non-significant results were found between the *Selector* vs *Non-Selector* groups, with the exception of CES question 3: "*Conversing with a familiar person over the telephone"* and CES question 4: "*Conversing with a stranger over the telephone."* More specifically, the *Selector* group had a significantly lower score than the *Non-Selector* group for 'Device C' relative to the 'Pre-device',

'Device A' and 'Device B' conditions for these two CES questions. These results suggests that for communicative contexts involving telephone use the *Selector* group rated themselves as less effective when using Device C.

Overall, the results of this sub-objective suggest that there were significant differences between the *Selector* group and the *Non-Selector* group based on total and mean communicative effectiveness scores across the device conditions, with the *Selector* group rating overall communicative effectiveness lower than the *Non-Selector* group. Based on individual CES items, there were no significant differences in ratings between groups with the exception of communicative effectiveness ratings related to telephone use. More specifically, the *Selector* group had significantly lower CES scores than the *Non-Selector* group for Device C suggesting that for communicative contexts involving telephone use the *Selector* group rated themselves as less effective when using Device C in comparison to the other devices trialed. Finally, the non-significant interactions suggests that the pattern of differences across the four device conditions was similar across the *Selector* and *Non-Selector* groups.

Voice Activity and Participation. The VAPP evaluated voice activity and participation between the *Selector* and *Non-Selector* groups across each of the three devices trialed. Total VAPP, VAPP ALS and VAPP PRS scores were examined. In addition, four subscale categories on the VAPP were analyzed. Significant results were found between the *Selector* and *Non-Selector* groups for Total VAPP and VAPP ALS demonstrating that the *Selector* group had significantly higher (worse) scores than the *Non-Selector* group across the device conditions. Further, there was not a significant 'device' condition effect between groups. No significant differences were found between *Selector* and *Non-Selector* groups for the VAPP PRS. These findings demonstrate that the ratings made by the *Selector* group showed a similar pattern of participation restrictions across device conditions as the ratings made by the *Non-Selector* group. When the four VAPP subscale categories were analyzed individually, overall, non-significant results were found between the *Selector* and *Non-Selector* groups, with the exception of VAPP Category 1: "*Self-perceived severity of voice problem."* These results suggest that the *Selector* group rated their perceived voice severity as significantly higher (worse) in

comparison to the *Non-Selector* group. This is an important finding because this specific VAPP category related to *self-perceived* voice severity could potentially serve as a predictor of those individuals who ultimately decide to select and adopt the use an amplification device in their daily lives versus those who do not adopt this assistive technology. McAuliffe and colleages (2017) explored predictors of communicative participation in individuals with PD and found that the the strongest predictor of restricted communicative participation was greater *perceived* speech impairment, as measured by the CPIB. Further exploration of *perceived* voice severity or *perceived* speech impairment as it relates to the adoption of speech amplification device use is warranted in a future study.

Overall, self-rated voice activity and participation differed significantly between the *Selector* and *Non-Selector* groups for the Total VAPP score, the VAPP activity limitation score, and self-perceived voice severity, with the *Selector* group demonstrating higher (worse) scores than the *Non-Selector* group for these outcome measures and subscales, but final device selection does not appear to be clearly related to any specific participation-based outcome measure.

Psychosocial Impact of Assistive Devices. The PIADS evaluated ratings of psychosocial impact between the *Selector* and *Non-Selector* groups across each of the three devices trials. PIADS Competence, PIADS Adaptability, and PIADS Self-Esteem scores were examined. There were no differences detected between the *Selector* and *Non-Selector* groups for PIADS Competence, PIADS Adaptability, and PIADS Self-esteem subscales. Further, there was no significant 'device' condition effect between groups. These results demonstrate that the psychosocial impact of using an amplification device based on the parameters of self-rated competence, adaptability and self-esteem were not rated differently between the *Selector* and *Non-Selector* groups and were not rated significantly different across the devices trialed.

In general, overall ratings of communicative effectiveness, and overall voice activity and participation ratings resulted in significant differences between participants who chose to select and purchase a device, and participants who did not purchase a device after study

completion. The *Selector* group reported lower total and mean communicative effectiveness scores and higher voice activity limitations and participation restrictions (including Total VAPP, VAPP ALS, VAPP subscales: self-perceived severity, effect on emotion, effect on social and daily communication) than the *Non-Selector* group. A possible interpretation of this result relates to a potential relationship with overall dysarthria severity or even overall severity of PD. It is possible that the *Selector* group were individuals with a more severe communication disorder, related either to hypophonia severity or the presence of other dysarthric symptoms associated with hypokinetic dysarthria. As a result, these individuals may experience less effective communication and increased voice activity limitations and participation restrictions in their daily lives, but during the device trials, experienced a greater perceived benefit to communicative effectiveness and voice activity and participation than without any speech amplification. Conversely, the *Non-Selector* group may not have experienced the same magnitude of perceived benefit to communicative participation, as a result of speech amplification, because of the presence of a less severe communication disorder.

When interpreting these results in relation to the demographic information of our participants with hypophonia, those that chose to select a device had been diagnosed with Parkinson's disease ranging from 8 years to 21 years. Comparing this age range to the *Non-Selector* group, the years since diagnosis was less, ranging between 0.5 years to 16 years. This group difference based on time since diagnosis may provide some support for an overall severity hypothesis and may have influenced the decision to purchase a device. Furthermore, when demographic information was reviewed related to self-rated level of speech usage (LSU; Baylor et al., 2008), the majority of participants from the *Selector* group reported speech usage as either 'undemanding' or 'intermittent'. In comparison, the majority of participants from the *Non-Selector* group reported speech usage as 'intermittent', with one participant reporting 'routine' speech usage. Based on the LSU scale, 'undemanding' speech usage is defined as being quiet for long periods of time almost every day, almost never talking for long periods, raising voice above a conversational level, participating in group discussions, or almost never give a speech or other presentation. 'Intermittent' speech usage is defined as being quiet for long periods of time on many days, with most talking being typical conversational speech, with

occasionally talking for longer periods, raising voice above a conversational level, participating in group discussions, or occasionally giving a speech or other presentation. 'Routine' speech usage is defined as frequent periods of talking on most days within typical conversational speech (Baylor et al., 2008). This additional contextual information provided by the LSU scale highlights that at baseline (i.e., pre-device use) the *Selector* group reported very limited speech usage which potentially has important consequences for communicative participation. When comparing the average CPIB summary scores between groups, the *Non-Selector* group had an average CBIP summary score of 18, while the *Selector* group had an average CPIB summary score of 10. CBIP summary scores range from 0 to 30, with higher scores being more favorable, and lower scores indicating greater interferences/restrictions to communicative participation. The differences in CPIB scores between groups suggest that the individuals in the *Selector* group reported greater interferences to communicative participation than the *Non-Selector* group. This finding also provides some additional support to the hypothesis that the *Selector* group may be more severe overall (either dysarthria severity or overall PD severity) than the *Non-Selector* group, evidenced by longer time since diagnosis, lower levels of speech usage, and greater interferences to communicative participation.

In the primary study by Knowles et al., (2020), the participants in the *Selector* group were not required formally to disclose the factors determining their decision to choose one device over another. However, some participants shared informally some reasons for choosing a specific device. For example, 41% of *Selectors* chose Device A. Several of these participants cited device portability, feelings of independence, and being able to use the device with more than one person at a time as factors influencing their decision to purchase this device. Eleven percent of *Selectors* chose Device B. Several of these participants reported they chose this device because of their ability to leave the loudspeaker in a specific location and the ability to hear their own amplified speech. Finally, 17% of *Selectors* chose Device C. Some reported reasons for choosing this device included that Device C worked well for their spouse who wore hearing aids, and that the other devices (Devices A and B) were not clear enough to be effective for their communication partner with a hearing impairment. This finding is a poignant reminder

that primary communication partners play an equally important role in device acceptance and decision-making and warrants future study.

Overall, it appears that for the 12 participants in the *Selector* group, self-rated communicative effectiveness, voice activity and participation, and the psychosocial impact of device use did not emerge clearly as a factor guiding the decision for *Selectors* to purchase one speech amplification device over another. What does emerge from the analysis of this data is that the *Selector* group appears to differentiate from the *Non-Selector* group based on lower participation-based patient reported scores at baseline, suggesting overall, more restricted communicative participation. When compared to the speech intelligibility findings reported by Knowles and colleagues, *Selectors*, especially those who purchased Devices B and C, demonstrated overall lower SNR values and were less intelligible to their communication partners in adverse listening conditions than the *Non-Selector* group who demonstrated greater variability in SNR and speech intelligibility performance (Knowles et al., 2020). Furthermore, when our results are situated within the context of other demographic information, it appears that the *Selector* group had Parkinson's disease for a longer amount of time, reported the most restricted daily speech usage, and reported greater interferences to communicative participation than the *Non-Selector* group. It appears that the decision for the *Selectors* to ultimately purchase a device (in comparison to the *Non-Selectors*) may be based on more restricted communicative participation and perhaps overall severity of hypophonia or overall PD severity. Furthermore, other factors described above such as personal device preferences based on device features, portability, discreteness, as well as the type and number of communication partners and environments unique to the individual, also appear to be factors contributing to the decision to ultimately purchase one device over another. Further delineation of the factors contributing to specific device selection warrants future study.

4.7 Strengths

Previous studies have investigated the effectiveness of speech amplification devices using objective measures such as SNR and speech intelligibility, however the present study appears to be the first to examine the effectiveness of amplification devices using

participation-based patient reported outcome measures. The present study is also one of only a few studies to examine the use of a two-way personal FM communication system as a speech amplification device for individuals with hypophonia.

4.8 Limitations

Although this study revealed several interesting findings, it is important to acknowledge some of its methodological limitations. The first methodological limitation relates to the heterogeneity and sample size of 17 participant dyads in the current study. Because of the modest sample size and heterogeneity of the HP participants, the ability to generalize findings may be limited, and as a result, definitive device recommendations cannot be provided based on participation-based outcome measures. Although study participants were recruited based on the presence of hypophonia as their primary dysarthric feature, there were factors not controlled for, such as severity of dysarthria. Since severity of speech is not necessarily related to interferences in communicative participation (Dykstra et al., 2015; McAuliffe et al., 2017), it is possible that other variables such as fatigue, mobility issues, and self-perceived severity may have influenced ratings of communicative participation not related to the specific device being trialed (Baylor et al., 2011; Dykstra et al., 2015; McAuliffe et al., 2017).

The second limitation relates to the amount of time our study participants had to trial each of the three amplification devices. Although the inclusion of longer-term device trial periods is a relative strength of this study, the one-week device trial period may not have provided adequate time to gauge the effect of an amplification device on communicative participation. It is possible that participants did not have ample opportunity to experience the specific communicative contexts/situations based on the questions included on the participation-based outcome measures. For example, on the CES, one item asks participants to rate communicative effectiveness while communicating when upset or angry, while another item asks participants to rate communicative effectiveness while speaking with a stranger on the phone. It is possible that some of these communicative situations were not experienced during the given week that participants were trialing a specific amplification device. Relatedly, all participants were instructed to use each amplification device over different occasions for at least two hours (Knowles et al, 2020).

Despite this instruction, several participants reported not adhering to this request, especially when they did not feel the device was beneficial or useful to their life circumstances (Knowles et al., 2020). This sentiment related to perceived usefulness or enjoyability of using the device may have resulted in even less opportunities to experience, and subsequently rate, communicative participation across the three device trials.

The third limitation relates to how some questions on the CES, such as those related to speaking on the telephone, could not be accurately rated by participants because of the specific configurations of the amplification devices that did not allow pairing of the telephone with the amplification device. For example, Device C, the personal FM system, is not able to be paired with a telephone because of its design and configuration and is therefore, not able to amplify the speech signal for the listener/communication partner on the other end of the telephone. Items related to telephone use is a limitation of this study and these results should therefore be interpreted with caution.

Finally, the fourth limitation relates to the type and frequency of speech usage and the personal communicative style of the participant with hypophonia as well as the individual communicative characteristics of the participant dyad. For example, participant dyads with more limited social networks, and who communicate primarily with each other may have been more inclined to rate higher communicative participation after using the personal FM system (Device C) as an amplification device. Conversely, participant dyads with broader social networks and those engage in more social activities with several communicative partners may have rated Device C as less favorable if it was perceived as creating restrictions to communicative participation because of its design to be used with a single communication partner. As a result, participants with broader social networks involving multiple communication partners, may prefer devices such as the Chattervox (Device A) or the NadyWA120BT (Device B) because of the external loudspeaker feature that can amplify the speech signal to be heard by multiple communication partners. The external loudspeaker feature may also improve communicative participation when communicating in these types of group contexts. Exploring how speech usage,

communicative style, and frequency influence device preference, device acceptance, and communicative participation warrants future study.

4.9 Future Directions

The results of the current study provide information and rationale from which future studies can be developed. Further exploration in this area can be pursued by adapting the research design to examine results in greater depth. A future study may wish to explore how communicative participation is experienced across different amplification devices using qualitative methods such as phenomenology. This methodology can seek to understand and explore the lived experiences of individuals with hypophonia and explore the variables or factors contributing to device preference and acceptance.

As discussed previously, the use of speech amplification devices while using the telephone represents a limitation of this study but is an interesting future direction for research. A future study may explore how various amplification devices can be modified and adapted to be paired with telephone use, and how modifications can potentially influence how communicative participation is experienced when using this mode of communication.

Based on the significant findings between selectors and non-selectors on certain CES and VAPP items/categories in the pre-device condition, a future study may wish to explore the development of a screening tool based on salient participation-based outcome measures or specific items on these measures (e.g., Total CES score, VAPP Category 1: *Self-perceived severity of voice problem,* VAPP ALS score) that could potentially help to predict individuals likely to adopt speech amplification device use versus non-adoptors.

Finally, as introduced previously as a study limitation, future research should seek to explore systematically how speech usage, communicative style, communicative frequency, and self-perceived speech severity influences communicative participation, device preference, and device acceptance.

4.10 Research and Clinical Implications

The results of this study add to the small but growing body of empirical literature on the use of speech amplification devices as a treatment option for individuals with hypophonia and provides preliminary data of how different speech amplification devices impact ratings of communicative participation. This study demonstrated that there are benefits to communicative participation when using any speech amplification device in comparison to not using an amplification device, and this benefit was demonstrated outside of a clinical setting. This finding is encouraging because it provides support that speech amplification devices may be one solution to improve the transfer-of-treatment issue, which has been long recognized as problematic in this clinical population. Further, the novel use of the Nady351VR, the personal FM communication system as a speech amplification device for hypophonia, also revealed that this device produced some of the highest ratings of communicative participation across several patient-reported outcome measures and subscales. Finally, the similarity in participation-based ratings made by primary communication partners provides support of the reliability of proxy ratings related to the construct of communicative participation in PD. Although it is preferable to have the individual with the communication disorder provide self-ratings or self-report, there may be situations or contexts in which the communication partner needs to provide ratings or perspective on their partner's behalf, such as in times of illness. In the pursuit of informing evidence-based prescription of speech amplification devices, the exploration of speech amplification devices from multiple perspectives including objective measures such as SNR and speech intelligibility (Knowles et al., 2020), in conjunction with participation-based patient reported outcome measures, allows for a more comprehensive and holistic approach to guide our understanding the variables that produce optimal outcomes for individuals with hypophonia using speech amplification.

4.11 Summary

The current study extended the research of Knowles et al. (2020) by evaluating how individuals with hypophonia and their primary communication partners rate communicative participation both before and after experience with three different speech

amplification devices outside of the laboratory. The overarching goal of this study was to provide specific recommendations for the use of amplification devices for this population from the perspective of patient-reported communicative participation.

The first objective of this study revealed that speech amplification improves ratings of communicative participation, regardless of the device trialed. A more detailed examination of results, however, does suggest differential effects of the three speech amplification devices, based on self-reported communicative effectiveness and voice activity and participation. Device B (NadyWA120BT) and Device C (Nady351VR) emerged as the two devices producing the highest ratings of communicative effectiveness in comparison to the pre-device condition.

The second objective of this study revealed that overall ratings of communicative effectiveness, voice activity and participation, and the psychosocial impact of using a speech amplification device were not rated significantly different across the three device conditions. Device B (NadyWA120BT) did emerge as producing higher ratings of communicative effectiveness related to speaking with a stranger over the telephone and speaking at a distance, in comparison to Device A or Device C.

The third objective of this study revealed overall ratings of communicative effectiveness, voice activity and participation, and the psychosocial impact of using a speech amplification device did not reveal significant differences between participants with hypophonia and their primary communication partners across the three device conditions. This result suggests that primary communication partners rate communicative participation similarly to their partners with hypophonia, indicating that the primary communication partners of our participants with hypophonia can appraise communicative participation similarly to the self-ratings made by their partner with hypophonia.

The fourth objective of this study revealed the Nady351VR (Device C) emerged as first rank in the device hierarchy as rated by our participants with hypophonia, followed by the NadyWA120BT (Device B) for participation-based outcome measures. The Chattervox (Device A) placed first in the hierarchy for some of the VAPP-related items, but overall, Device C and B were consistently rated in first or second position. When

comparing the hierarchies that emerged from the current study based on communicative participation outcome measures with the primary study conducted by Knowles et al., there were only two specific CES items, *having a conversation with a family member or friends at home, and speaking to a friend when emotionally upset or you are angry*, and two PIADS subscales, *competence and self-esteem,* that mapped directly onto Knowles' (2020) hierarchies based on SNR and speech intelligibility.

Finally, the fifth objective of this study revealed differences between the participants who elected to purchase a device with those who did not elect to purchase a device, based on overall ratings of communicative effectiveness and voice activity and participation. More specifically, the participants who chose to purchase a device self-rated lower communicative effectiveness and increased activity limitations and participation restrictions in comparison to the participants who did not choose to purchase an amplification device. A related consideration in our interpretation of this finding could be reflective of overall severity of PD for the Selector group.

This study has revealed novel and potentially valuable information concerning the effect of speech amplification devices for individuals with Parkinson's disease and hypophonia. The results and implications of this research have contributed to an increased understanding of how communicative participation is experienced within this population as a result of speech amplification. The findings from this line of research will contribute to a small but growing body of literature regarding the effect of speech amplification for individuals with hypophonia and PD. It can be argued that in order to provide optimal evidence-based prescription of speech amplification devices, the inclusion of communicative participation outcome measurement is essential to ensure a multi-dimensional and comprehensive approach to device prescription.

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Appendix A: HSREB Initial Approval Notice

Western Research

Research Ethics

Western University Health Science Research Ethics Board
HSREB Delegated Initial Approval Notice

Principal Investigator: Dr. Scott Adams
Department & Institution: Health Sciences\Communication Sciences & Disorders, Western University

HSREB File Number: 106169
Study Title: A comparison of voice amplifiers and personal communication systems in individuals with Parkinson's disease
Sponsor:

HSREB Initial Approval Date: April 07, 2015
HSREB Expiry Date: April 07, 2016

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Recruitment Items	Classroom announcement	2015/02/11
Other	ClinicalTrials.gov Identifier: NCT02407067	2015/04/01
Letter of Information & Consent	PD participants	2015/03/30
Letter of Information & Consent	LOI CGs clean	2015/02/11
Letter of Information	LOI listeners clean	2015/02/11
Other	Forms, questionnaires and rating scales (received Dec.15/14)	
Western University Protocol		2015/02/11

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the above named study, as of the HSREB Initial Approval Date noted above.

HSREB approval for this study remains valid until the HSREB Expiry Date noted above, conditional to timely submission and acceptance of HSREB Continuing Ethics Review.

The Western University HSREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use Guideline for Good Clinical Practice Practices (ICH E6 R1), the Ontario Personal Health Information Protection Act (PHIPA, 2004), Part 4 of the Natural Health Product Regulations, Health Canada Medical Device Regulations and Part C, Division 5, of the Food and Drug Regulations of Health Canada.

Members of the HSREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

[redacted]

Ethics Officer, on behalf of Dr. Marcelo Kremenchutzky, HSREB Vice Chair

Ethics Officer to Contact for Further Information

Erika Basile	Grace Kelly	Mina Mekhail	Vicki Tran
[redacted]	[redacted]	[redacted]	[redacted]

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Appendix B: HSREB Amendment Approval Notice

Western Research

Western University Health Science Research Ethics Board
HSREB Amendment Approval Notice

Principal Investigator: Dr. Scott Adams
Department & Institution: Health Sciences\Communication Sciences & Disorders, Western University

Review Type: Delegated
HSREB File Number: 106169
Study Title: A comparison of voice amplifiers and personal communication systems in individuals with Parkinson's disease

HSREB Amendment Approval Date: May 24, 2017
HSREB Expiry Date: April 07, 2018

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Revised Letter of Information & Consent	Revised Parkinson LOI clean	2017/04/27
Revised Letter of Information & Consent	Revised communication partner LOI clean	2017/04/27
Revised Letter of Information & Consent	Revised listener LOI clean	2017/04/27
Revised Western University Protocol	Received 19 May 2017	2017/04/24

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the amendment to the above named study, as of the HSREB Initial Approval Date noted above.

HSREB approval for this study remains valid until the HSREB Expiry Date noted above, conditional to timely submission and acceptance of HSREB Continuing Ethics Review.

The Western University HSREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use Guideline for Good Clinical Practice Practices (ICH E6 R1), the Ontario Personal Health Information Protection Act (PHIPA, 2004), Part 4 of the Natural Health Product Regulations, Health Canada Medical Device Regulations and Part C, Division 5, of the Food and Drug Regulations of Health Canada.

Members of the HSREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

[redacted]

Ethics Officer, on behalf of Dr. Marcelo Kremenchutzky, HSREB Vice Chair

EO: Erika Basile ___ Grace Kelly ___ Katelyn Harris___ Nicola Morphet ___ Karen Gopaul ___ Patricia Sargeant ✓

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Appendix C: Level of Speech Usage

The Levels of Speech Usage: A Self-Report Scale

Unique ID: _____

While communication is important to everyone, different people use their speech in different ways. Think of how you have typically used your speech over the *past year.* Choose the category below that best describes you.

_____ ***Undemanding:***

Quiet for long periods of time **almost every day**
Almost never:
- Talk for long periods
- Raise your voice above a conversational level
- Participate in group discussions, give a speech or other presentation

_____ ***Intermittent:***
Quiet for long periods of time on **many days**
Most talking is **typical conversational speech**
Occasionally:
- Talk for longer periods
- Raise voice above a conversational level
- Participate in group discussions, give a speech or other presentation

_____ ***Routine:***
Frequent periods of talking on **most days**
Most talking is **typical conversational speech**
Occasionally:
- Talk for longer periods
- Raise voice above a conversational level
- Participate in group discussions, give a speech or other presentation

_____ ***Extensive:***
Speech usage **consistently goes beyond everyday conversational speech**
Regularly:
- Talk for long periods
- Talk in a loud voice
- Participate in group discussions, give presentations or performances

Although the demands on your speech are often high, you are able to continue with most work or social activities even if your speech is not perfect

_____ ***Extraordinary:***
Very high speech demands
Regularly:
- Talk for long periods of time
- Talk with loud or expressive speech or
- Give presentations or performances

The success of your work of personal goals depends almost entirely on the quality of your speech and voice

Appendix D: Communication Participation Item Bank

The Communicative Participation Item Bank – General Short Form

Instructions:
The following questions describe a variety of situations in which you might need to speak to others. For each question, please mark how much your condition interferes with your participation in that situation. By "condition" we mean ALL issues that may affect how you communicate in these situations including speech conditions, any other health conditions, or features of the environment. If your speech varies, think about an AVERAGE day for your speech – not your best or your worst days.

	Not at all (3)	A little (2)	Quite a bit (1)	Very much (0)
1. Does your condition interfere with... **...talking with people you know?**	○	○	○	○
2. Does your condition interfere with... **...communicating when you need to say something quickly?**	○	○	○	○
3. Does your condition interfere with... **...talking with people you do NOT know?**	○	○	○	○
4. Does your condition interfere with... **...communicating when you are out in your community (e.g. errands; appointments)?**	○	○	○	○
5. Does your condition interfere with... **...asking questions in a conversation?**	○	○	○	○
6. Does your condition interfere with... **...communicating in a small group of people?**	○	○	○	○
7. Does your condition interfere with... **...having a long conversation with someone you know about a book, movie, show or sports event?**	○	○	○	○
8. Does your condition interfere with... **... giving someone DETAILED information?**	○	○	○	○
9. Does your condition interfere with... **...getting your turn in a fast-moving conversation?**	○	○	○	○
10. Does your condition interfere with... **...trying to persuade a friend or family member to see a different point of view?**	○	○	○	○

Appendix E: Communicative Effectiveness Survey

Communicative Effectiveness Survey

Participant Code: _____ Date: _____

In this survey we ask you to rate how effective **your speech** is in different communication situations. Please read each statement. Then rate how effectively you communicate in that situation. If you feel your speech is very effective, mark the 4. If your speech does not allow you to communicate at all in a situation, mark the 1. Feel free to use any number on the scale.

1. Having a conversation with a family member or friends at home.

Not at all effective			Very effective
1	2	3	4

2. Participating in conversation with strangers in a quiet place.

Not at all effective			Very effective
1	2	3	4

3. Conversing with a familiar person over the telephone.

Not at all effective			Very effective
1	2	3	4

4. Conversing with a stranger over the telephone.

Not at all effective			Very effective
1	2	3	4

5. Being part of a conversation in a noisy environment (social gathering).

Not at all effective			Very effective
1	2	3	4

6. Speaking to a friend when you are emotionally upset or you are angry.

Not at all effective			Very effective
1	2	3	4

7. Having a conversation while traveling in a car.

Not at all effective			Very effective
1	2	3	4

8. Having a conversation with someone at a distance (across a room).

Not at all effective			Very effective
1	2	3	4

Note. From "The communicative effectiveness survey: Investigating its item-level psychometric properties," by N. J. Donovan, C. A. Velozo, and J. C. Rosenbek, 2007, *Journal of Medical Speech-Language Pathology, 15,* p. 447.

Appendix F: Voice Participation Activity Profile

Appendix. Voice Activity and Participation Profile.

Self-perceived severity of voice problem

1. How severe is your voice problem now?

Normal |_____| Severe

Note: The following line is used for responding to each question and it appears under each question in the original profile. These lines are omitted in this Appendix for brevity.

Never |_____| Always

Please answer the following questions by putting a cross ("X") on the line which best represents your answer. A cross towards the left side means you are never affected while a cross towards the right side means you are always affected.

Effect on job

2. Is your job affected by your voice problem?
3. In the last 6 months, have you thought of changing your job because of your voice problem?
4. Has your voice problem created any pressure on your job?
5. In the last 6 months, has your voice problem affected your decisions for your future career?

Effect on daily communication

6. Do people ask you to repeat what you have just said because of your voice problem?
7. In the last 6 months, have you ever avoided talking to people because of your voice problem?
8. Do people have difficulty understanding you on the phone because of your voice problem?
9. In the last 6 months, have you reduced the use of the telephone because of your voice problem?
10. Does your voice problem affect your communication in quiet environments?
11. In the last 6 months, have you ever avoided having conversations in quiet environments because of your voice problem?
12. Does your voice problem affect your communication in noisy environments?
13. In the last 6 months, have you ever avoided having conversations in noisy environments because of your voice problem?
14. Does your voice problem affect your message when speaking to a group of people?
15. In the last 6 months, have you ever avoided having conversations in a group because of your voice problem?
16. Does your voice problem affect getting your message across?
17. In the last 6 months, have you ever avoided speaking because of your voice problem?

Effect on social communication

18. Does your voice problem affect you in social activities?
19. In the last 6 months, have you ever avoided social activities because of your voice problem?
20. Are your family, friends, or co-workers annoyed by your voice problem?
21. In the last 6 months, have you ever avoided communicating with your family, friends, or co-workers because of your voice problem?

Effect on your emotion

22. Do you feel upset about your voice problem?
23. Are you embarrassed by your voice problem?
24. Do you have low self-esteem because of your voice problem?
25. Are you worried about your voice problem?
26. Do you feel dissatisfied because of your voice problem?
27. Does your voice problem affect your personality?
28. Does your voice problem affect your self image?

Appendix G: Psychosocial Impact of Assistive Devices Scale

Psychosocial **I**mpact of **A**ssistive **D**evices **S**cale (PIADS) Today's Date: _____
month/day/year

Client Name:_____ ☐ male ☐ female
(last name, then first name)

Diagnosis:_____ Date of Birth:_____
month/day/year

The form is being filled out at (choose one) **1.** ☐ home **2.** ☐ a clinic **3.** ☐ other (describe):_____

The form is being filled out by (choose one) **1.** ☐ the client, without any help **2.** ☐ the client, with help from the caregiver (e.g., client showed or told caregiver what answers to give) **3.** ☐ the caregiver on behalf of the client, without any direction from the client **4.** ☐ other (describe): _____

Each word or phrase below describes how using an assistive device may affect a user. Some might seem unusual but it is important that you answer every one of the 26 items. So, for each word or phrase, put an "X" in the appropriate box to show how you are affected by using the _____ (device name).

	Decreases	-3	-2	-1	0	1	2	3	Increases
1)	competence	☐	☐	☐	☐	☐	☐	☐	
2)	happiness	☐	☐	☐	☐	☐	☐	☐	
3)	independence	☐	☐	☐	☐	☐	☐	☐	
4)	adequacy	☐	☐	☐	☐	☐	☐	☐	
5)	confusion	☐	☐	☐	☐	☐	☐	☐	
6)	efficiency	☐	☐	☐	☐	☐	☐	☐	
7)	self-esteem	☐	☐	☐	☐	☐	☐	☐	
8)	productivity	☐	☐	☐	☐	☐	☐	☐	
9)	security	☐	☐	☐	☐	☐	☐	☐	
10)	frustration	☐	☐	☐	☐	☐	☐	☐	
11)	usefulness	☐	☐	☐	☐	☐	☐	☐	
12)	self-confidence	☐	☐	☐	☐	☐	☐	☐	
13)	expertise	☐	☐	☐	☐	☐	☐	☐	
14)	skillfulness	☐	☐	☐	☐	☐	☐	☐	
15)	well-being	☐	☐	☐	☐	☐	☐	☐	
16)	capability	☐	☐	☐	☐	☐	☐	☐	
17)	quality of life	☐	☐	☐	☐	☐	☐	☐	
18)	performance	☐	☐	☐	☐	☐	☐	☐	
19)	sense of power	☐	☐	☐	☐	☐	☐	☐	
20)	sense of control	☐	☐	☐	☐	☐	☐	☐	
21)	embarrassment	☐	☐	☐	☐	☐	☐	☐	
22)	willingness to take chances	☐	☐	☐	☐	☐	☐	☐	
23)	ability to participate	☐	☐	☐	☐	☐	☐	☐	
24)	eagerness to try new things	☐	☐	☐	☐	☐	☐	☐	
25)	ability to adapt to the activities of daily living	☐	☐	☐	☐	☐	☐	☐	
26)	ability to take advantage of opportunities	☐	☐	☐	☐	☐	☐	☐	

For more information about PIADS contact: Jeffrey W. Jutai, PhD, University of Ottawa, 613-562-5800 x8218. email: jjutai@uottawa.ca

Revised August 14, 2000 (Office Use Only – ID# _____) Version 3.0

Appendix H: Letter of Information: Participants with PD

Western HealthSciences

Health and Rehabilitation Sciences

Project Title:
A Comparison of Voice Amplifiers and Personal Communication Systems in Individuals with Parkinson's Disease

Principal Investigator:
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School of Communication Sciences and Disorders; Clinical Neurological Sciences
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Health and Rehabilitation Sciences, Western University

Letter of Information for Participants with Parkinson's Disease

1. **Invitation to Participate**

   You are invited to participate in this research study investigating the effectiveness of three types of assistive communication devices for individuals with Parkinson's disease (PD) and hypophonia (reduced speech volume) because you have been diagnosed with idiopathic PD and hypophonia.

2. Purpose of the Letter

The purpose of this letter is to provide you with information required for you to make an informed decision regarding participation in this research.

3. Purpose of this Study

The purpose of this study is to compare the performance of two voice amplifier systems and a personal communication system in individuals with a speech disorder related to Parkinson's disease. The performance of these two devices will be measured using 1) measures of speech intelligibility and intensity in quiet and noise and 2) with patient and communication partner (i.e. spouse) questionnaires and rating scales.

4. Inclusion Criteria

To be eligible to participate as a PD subject in this study, individuals must have been diagnosed with idiopathic PD at least six months ago, be stabilized on antiparkinsonian medication, and exhibit mild to moderate signs and symptoms of PD and hypophonia. Additionally, individuals must be between 50 and 85 years old, be in good general health, and speak English as their first language.

5. Exclusion Criteria

Individuals who have severe signs and symptoms of PD, a history of stroke or an additional neurological or motor control disorder, or a history of a speech impairment (that is unrelated to PD) are not eligible to participate in this study. Additionally, individuals who have received speech therapy within the past twelve months will be ineligible to participate.

6. Study Procedures

If you agree to participate, you will first be asked to take basic hearing and cognitive screening tests, to provide your age as well as general information about your medical, speech and hearing, and neurological history. In addition, you will be asked to complete four questionnaires related to your communicative effectiveness, speech usage, and social communication.

The study involves comparing three assistive communication devices and includes three parts. The first part involves **a one hour visit** to Professor Scott Adams' lab (which is located in room 2212 at Elborn College) and will involve using the three devices while reading aloud sentences and describing pictures in varying levels of background noise. During the speech tasks, you will be asked to wear a headset microphone that will record your speech on a computer. Your speech recordings will be measured with acoustic instruments (i.e. speech intensity) and also transcribed and rated by a group of naïve listeners. In addition, after each sentence that you say aloud, your communication partner (i.e. spouse) will attempt to write down all of the words that you have spoken. After you have finished talking with each device you will be asked to rate your experience with the device using a questionnaire.

The second part of the study involves 3 **device trial periods that are each one week in length**. During each of these one week trial periods, you will be asked to take one of the devices home with you and use the device during everyday conversations with your communication partner. During each one week trial period, you will be asked to use the device at least three times for a period of at least one hour each time. You are encouraged to use the device more frequently and in a variety of social contexts. You will be given a device diary to write down the times and contexts in which you used the device. Following each trial period, you will return to Professor Scott Adams' lab for a one hour visit. During these 3 **one hour visits** you will complete several questionnaires related to your experiences and impressions of the device. You will also be encouraged to discuss your experiences and concerns with the device.

The third part of the study involves a one hour visit at 6 months following the completion of the last trial period. This 6 month follow-up visit will only take place if you decide to purchase one of the 3 devices for regular use in your everyday conversations. If you decide not to purchase one of the three study devices, or you decide to purchase a different amplification device, then the 6 month follow-up visit will not take place. During the **one hour follow-up visit** you will complete several questionnaires related to your experiences and impressions of the device.

The total participation time for this study will be 5 hours if you are involved in all 3 parts of the study. If you are not involved in the 6 month follow-up then the total participation time will be 4 hours. There will be a total of 20 individuals with Parkinson's disease, 20 communication partners and 10 naïve listeners participating in this study.

7. Assistive Communication Devices

The three devices include 1) a wired voice amplifier, 2) a wireless voice amplifier, and 3) a personal communication system. The wired voice amplifier is a ChatterVox. This amplifier includes a headset microphone wired to a speaker/amplifier unit that is worn on a waist belt. The second device is a wireless Nady voice amplifier that includes a wireless headset microphone that transmits to a portable speaker. The ChatterVox and Nady voice amplifiers were selected because they are typical of the types of voice amplifiers that are frequently recommended and prescribed to individuals with PD in Ontario.

The personal communication system is a Nady communication system. This system includes a light-weight, pocket-sized transmitter unit with a head-set microphone and a nearly identical, pocket-sized receiver unit with a set of small headphones. These units can be carried in a breast-pocket or attached to a waist-belt with a clip. The transmitter and receiver units are wireless and communicate via an FM signal. The communication range of the units is approximately 30 meters. In this study, the individual with PD will wear the transmitter/microphone unit and the communication partner (CP) participant will wear the receiver/headphone unit. FM systems like the Nady personal communication system have been frequently prescribed and has been used in several previous studies of individuals with hearing impairment.

8. Possible Risks and Harms

There are no known or anticipated risks associated with participation in this study. The experiment will be conducted in a safe, hygienic, university lab with adequate lighting and ventilation. The equipment (communication devices, headset microphones, chair) will be adjusted to your comfort level. The experimental procedures will require very minimal physical effort. To help counteract any fatigue you may experience through the duration of the experiment, you will be given rest breaks at approximately ten-minute intervals or more frequently if requested. The only time discomfort may arise is when you are asked to speak during multi-talker background noise, which may cause some feelings of frustration or irritation. The level of background noise used in this study is 65 dB SPL, which is not an excessive level and will not cause hearing damage (65 dB SPL is comparable to moderate cafeteria noise).

Your participation in this study will cause a delay of approximately three weeks in the usual standard of care related to the prescription of a voice amplifier for your condition. During this delay period you will have the opportunity to evaluate two voice amplifiers for one week each and this experience may help to guide your later voice amplifier prescription decision.

9. Possible Benefits

The potential benefit to participants with PD is that experience with different communication devices under various conditions may enable them to make more informed decisions regarding their own treatment options for hypophonia. The potential benefits to society include the improvement of communication device prescription, the development of more effective communication devices, and a framework for future efficacy research in PD.

10. Compensation

You will not be compensated for your participation in this study. However, on-site parking will be complimentary on the days of participation regardless of whether you complete the study. A free daily visitor's parking pass will be provided to you upon your arrival to the Elborn College parking lot.

11. Voluntary Participation

Participation in this study is voluntary. You may refuse to participate, refuse to answer any questions or withdraw from the study at any time with no effect on your future treatment or medical care.

12. Confidentiality

All data collected will remain confidential. Your name and any identifying information will be collected separately from the data. All data collected with no personal identifiers will be retained for five years after the publication of the study results. If you choose to withdraw from this study, your data will be immediately removed and destroyed from our database. Our research records will be locked in a cabinet in the principal investigator's secure lab in Elborn College, University of Western Ontario. Only members of the

research team will review the identified audio recordings. Listener participants will make perceptual ratings from de-identified audio recordings. All other data collected will remain accessible only to the investigators of this study. Representatives of The University of Western Ontario Health Sciences Research Ethics Board may contact you or require access to your study-related records to monitor the conduct of the research. In addition, representatives of the Lawson Quality Assurance (QA) Education Program may look at study data for quality assurance purposes.

13. Contacts for Further Information

If you require any further information regarding this research project or your participation in the study, you may contact Dr. Scott Adams [redacted]

If you have any questions about your rights as a research participant or the conduct of this study, you may contact Dr. David Hill, Scientific Director, Lawson Health Research Institute at [redacted]

14. Publication

If the results of the study are published, your name will not be used and no information that discloses your identity will be released or published. If you would like to receive a copy of any potential study results, please contact Dr. Scott Adams.

This letter is yours to keep for future reference.

Appendix I: Consent Form: Participants with PD

Western HealthSciences

Health and Rehabilitation Sciences

Consent Form

Project Title:
A Comparison of Voice Amplifiers and Personal Communication Systems in Individuals with Parkinson's Disease

Principal Investigator:
Scott Adams, PhD
Professor, School of Communication Sciences and Disorders; Clinical Neurological Sciences
Western University
[redacted]

Co-Investigators:
Dr. Mandar Jog, MD, FRCPC
Director, Movement Disorders Program; Clinical Neurological Sciences
London Health Science Centre, University Campus, and Western University

Allyson Dykstra, PhD, Assistant Professor
School of Communication Sciences and Disorders
Western University

Thea Knowles, BA, MClSc/PhD Candidate, Speech and Language Science
Health and Rehabilitation Sciences, Western University

I have read the Letter of Information and have had the nature of the study explained to me, and I agree to participate. All questions have been answered to my satisfaction. I do not waive my legal rights by signing this consent.

Signature of Research Participant	Printed Name	Date
Signature of Person Obtaining Informed Consent	Printed Name	Date

Appendix J: Letter of Information: Primary Communication Partners

Western HealthSciences

Health and Rehabilitation Sciences

Project Title:
A Comparison of Voice Amplifiers and Personal Communication Systems in Individuals with Parkinson's Disease

Principal Investigator:
Scott Adams, PhD
Professor
School of Communication Sciences and Disorders; Clinical Neurological Sciences
Western University
[redacted]

Co-Investigators:
Dr. Mandar Jog, MD, FRCPC
Director
Movement Disorders Program; Clinical Neurological Sciences
London Health Science Centre, University Campus, and Western University

Allyson Dykstra, PhD
Assistant Professor
School of Communication Sciences and Disorders
Western University

Thea Knowles, BA,
MClSc/PhD Candidate, Speech and Language Science
Health and Rehabilitation Sciences, Western University

Letter of Information for Communication Partner Participants

1. **Invitation to Participate**

   You are invited to participate in this research study investigating the effectiveness of three types of assistive communication devices for individuals with Parkinson's disease (PD) and hypophonia (reduced speech volume) because you are a primary communication partner with an individual who has been diagnosed with idiopathic PD and hypophonia.

2. Purpose of the Letter

The purpose of this letter is to provide you with information required for you to make an informed decision regarding participation in this research.

3. Purpose of this Study

The purpose of this study is to compare the performance of two voice amplifier systems and a personal communication system in individuals with a speech disorder related to Parkinson's disease. The performance of these two devices will be measured using 1) measures of speech intelligibility and intensity in quiet and noise and 2) with patient and communication partner (i.e. spouse) questionnaires and rating scales.

4. Inclusion Criteria

To be eligible to participate in this study, individuals must be between 18 and 85 years old and speak English as their first language.

5. Exclusion Criteria

Individuals who have a severe or profound hearing impairment or an inability to read and write are not eligible to participate in this study.

6. Study Procedures

If you agree to participate, you will first be asked to take basic hearing screening test and to provide your age. In addition, you will be asked to complete four questionnaires related the communicative effectiveness, speech usage, and social communication of your communication partner who has Parkinson's disease.

The study involves comparing three assistive communication devices and involves three parts. The first part involves **a one hour visit** to Professor Scott Adams' lab (which is located in room 2212 at Elborn College) and will involve listening to the three devices while the person with Parkinson's disease reads aloud sentences and describes pictures in varying levels of background noise. During the speech tasks, you will be asked to listen carefully and attempt to write down the words in each sentence that the person with PD

says aloud. The person with PD will be asked to pause after each sentence to allow you enough time to repeat aloud the sentence. There will be a total of 72 sentences to be repeated. After you have finished listening to all of the sentences you will be asked to rate your experience with each of the two devices using a questionnaire.

The second part of the study involves 3 **device trial periods that are each one week in length**. During each of these one week trial periods, the individual with PD will be asked to take one of the devices home and use the device during everyday conversations with you. During each one week trial period, the person with PD will be asked to use the device in conversations with you at least three times for a period of at least one hour each time. In addition, the person with PD will be encouraged to use the device more frequently and in a variety of social contexts. The person with PD will be given a device diary to write down the times and contexts in which they used the device. Following each trial period, you will return to Professor Scott Adams' lab for a one hour visit. During these 3 **one hour visits** you will complete several questionnaires related to your experiences and impressions listening to the person with PD use the device. You will also be encouraged to discuss your experiences and concerns with the device.

The third part of the study involves a one hour visit at 6 months following the completion of the last trial period. This 6 month follow-up visit will only take place if the person with PD decides to purchase one of the 3 devices for regular use in everyday conversations. If the person with PD decides not to purchase one of the three study devices, or decides to purchase a different amplification device, then the 6 month follow-up visit will not take place. During the **one hour follow-up visit** you will complete several questionnaires related to your experiences and impressions listening to the person with PD use the device.

The total participation time for this study will be 5 hours if you are involved in all 3 parts of the study. If you are not involved in the 6 month follow-up then the total participation time will be 4 hours. There will be a total of 20 individuals with Parkinson's disease, 20 communication partners and 10 naïve listeners participating in this study.

7. Assistive Communication Devices

The three devices include 1) a wired amplifier, 2) a wireless voice amplifier, and 3) a personal communication system. The wired voice amplifier is a ChatterVox. This

amplifier includes a headset microphone wired to a speaker/amplifier unit that is worn on a waist belt. The second device is a wireless Nady voice amplifier that includes a wireless headset microphone that transmits to a portable speaker. The ChatterVox and Nady voice amplifiers were selected because they are typical of the types of voice amplifiers that are frequently recommended and prescribed to individuals with PD in Ontario.

The personal communication system is a Nady communication system. This system includes a light-weight, pocket-sized transmitter unit with a head-set microphone and a nearly identical, pocket-sized receiver unit with a set of small headphones. These units can be carried in a breast-pocket or attached to a waist-belt with a clip. The transmitter and receiver units are wireless and communicate via an FM signal. The communication range of the units is approximately 30 meters. In this study, the individual with PD will wear the transmitter/microphone unit and the communication partner (CP) participant will wear the receiver/headphone unit. FM systems like the Nady personal communication system have been frequently prescribed and has been used in several previous studies of individuals with hearing impairment.

8. Possible Risks and Harms

There are no known or anticipated risks associated with participation in this study. The experiment will be conducted in a safe, hygienic, university lab with adequate lighting and ventilation. The experimental procedures will require very minimal physical effort. To help counteract any fatigue you may experience through the duration of the experiment, you will be given rest breaks at approximately ten-minute intervals or more frequently if requested. The only time discomfort may arise is when you are asked to listen during multi-talker background noise, which may cause some feelings of frustration or irritation. The level of background noise used in this study is 65 dB SPL, which is not an excessive level and will not cause hearing damage (65 dB SPL is comparable to moderate cafeteria noise).

9. Possible Benefits

There is no direct benefit to participation in this study. The potential benefit to participants with PD is that experience with different communication devices under various conditions may enable them to make more informed decisions regarding their own treatment options for hypophonia. The potential benefits to society include the

improvement of communication device prescription, the development of more effective communication devices, and a framework for future efficacy research in PD.

10. Compensation

You will not be compensated for your participation in this study. However, on-site parking will be complimentary on the days of participation regardless of whether you complete the study. A free daily visitor's parking pass will be provided to you upon your arrival to the Elborn College parking lot.

11. Voluntary Participation

Participation in this study is voluntary. You may refuse to participate, refuse to answer any questions or withdraw from the study at any time with no effect on your future treatment or medical care.

12. Confidentiality

All data collected will remain confidential. Your name and any identifying information will be collected separately from the data. All data collected with no personal identifiers will be retained for five years after the publication of the study results. If you choose to withdraw from this study, your data will be immediately removed and destroyed from our database. Our research records will be locked in a cabinet in the principal investigator's secure lab in Elborn College, University of Western Ontario. Only members of the research team will review the identified audio recordings. Listener participants will make perceptual ratings from de-identified audio recordings. All other data collected will remain accessible only to the investigators of this study. Representatives of The University of Western Ontario Health Sciences Research Ethics Board may contact you or require access to your study-related records to monitor the conduct of the research. In addition, representatives of the Lawson Quality Assurance (QA) Education Program may look at study data for quality assurance purposes.

13. Contacts for Further Information

If you require any further information regarding this research project or your participation in the study, you may contact Dr. Scott Adams at [redacted]

If you have any questions about your rights as a research participant or the conduct of this study, you may contact Dr. David Hill, Scientific Director, Lawson Health Research Institute at [redacted]

14. Publication

If the results of the study are published, your name will not be used and no information that discloses your identity will be released or published. If you would like to receive a copy of any potential study results, please contact Dr. Scott Adams.

This letter is yours to keep for future reference.

Appendix K: Consent Form: Primary Communication Partners

Western HealthSciences

Health and Rehabilitation Sciences

Consent Form

Project Title:
A Comparison of Voice Amplifiers and Personal Communication Systems in Individuals with Parkinson's Disease

Principal Investigator:
Scott Adams, PhD
Professor
School of Communication Sciences and Disorders; Clinical Neurological Sciences
Western University
[redacted]

Co-Investigators:
Dr. Mandar Jog, MD, FRCPC
Director, Movement Disorders Program; Clinical Neurological Sciences
London Health Science Centre, University Campus, and Western University

Allyson Dykstra, PhD
Assistant Professor, School of Communication Sciences and Disorders
Western University

Thea Knowles, BA, MClSc/PhD Candidate, Speech and Language Science
Health and Rehabilitation Sciences, Western University

I have read the Letter of Information and have had the nature of the study explained to me, and I agree to participate. All questions have been answered to my satisfaction. I do not waive my legal rights by signing this consent.

Signature of Research Participant	Printed Name	Date
Signature of Person Obtaining Informed Consent	Printed Name	Date

Appendix L: Inter-rater reliability

Reliability Statistics	
Cronbach's alpha	**N of Items**
1	**2**

Intraclass Correlation Coefficient							
	Intraclass Correlation[b]	**95% Confidence Interval**		**F Test with True Value 0**			
		Lower Bound	**Upper Bound**	**Value**	**Df1**	**Df2**	**Sig.**
Single Measures	**1.000[a]**	**1.000**	**1.000**	**212993.046**	**9**	**9**	**.000**
Average Measures	**1.000[c]**	**1.000**	**1.000**	**212993.046**	**9**	**9**	**.000**

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.
b. Type A intraclass correlation coefficients using an absolute agreement definition.
c. This estimate is computed assuming the interaction effect is absent because it is not estimate otherwise.

Appendix M: Intra-rater reliability

Reliability Statistics	
Cronbach's alpha	**N of Items**
1	**2**

Intraclass Correlation Coefficient							
	Intraclass Correlation[b]	**95% Confidence Interval**		**F Test with True Value 0**			
		Lower Bound	**Upper Bound**	**Value**	**Df1**	**Df2**	**Sig.**
Single Measures	**1.000[a]**	**1.000**	**1.000**	**15814191.21**	**9**	**9**	**.000**
Average Measures	**1.000[c]**	**1.000**	**1.000**	**15814191.21**	**9**	**9**	**.000**

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.
b. Type A intraclass correlation coefficients using an absolute agreement definition.
c. This estimate is computed assuming the interaction effect is absent because it is not estimate otherwise.

Appendix N: Repeated measures MANOVA: Communicative Effectiveness (Objective 1A)

Descriptive Statistics

	Mean	Std. Deviation	N
Q1CES1	2.93	.730	14
Q1CES2	3.14	.663	14
Q1CES3	3.14	.770	14
Q1CES4	3.21	.699	14
Q2CES1	2.43	.938	14
Q2CES2	2.79	.699	14
Q2CES3	2.86	.864	14
Q2CES4	2.71	.914	14
Q3CES1	2.57	.938	14
Q3CES2	2.64	.745	14
Q3CES3	2.86	.535	14
Q3CES4	2.21	1.051	14
Q4CES1	2.29	1.139	14
Q4CES2	2.36	.633	14
Q4CES3	2.57	.514	14
Q4CES4	1.93	.997	14
Q5CES1	1.93	.917	14
Q5CES2	2.43	.852	14
Q5CES3	2.93	.616	14
Q5CES4	2.79	.579	14
Q6CES1	2.00	.877	14
Q6CES2	2.14	.949	14
Q6CES3	2.64	.929	14
Q6CES4	2.71	.611	14
Q7CES1	2.21	.975	14
Q7CES2	2.86	.663	14
Q7CES3	2.79	.802	14
Q7CES4	3.00	.784	14
Q8CES1	2.07	.917	14
Q8CES2	2.71	.825	14
Q8CES3	3.36	.842	14
Q8CES4	3.29	.469	14

Multivariate Tests[a]

Effect			Value	F	Hypothesis df	Error df
Between Subjects	Intercept	Pillai's Trace	.995	160.180[b]	8.000	6.000
		Wilks' Lambda	.005	160.180[b]	8.000	6.000
		Hotelling's Trace	213.573	160.180[b]	8.000	6.000
		Roy's Largest Root	213.573	160.180[b]	8.000	6.000
Within Subjects	prepost	Pillai's Trace	.[c]	.	.	.
		Wilks' Lambda	.[c]	.	.	.
		Hotelling's Trace	.[c]	.	.	.
		Roy's Largest Root	.[c]	.	.	.

Multivariate Tests[a]

Effect			Sig.	Partial Eta Squared
Between Subjects	Intercept	Pillai's Trace	.000	.995
		Wilks' Lambda	.000	.995
		Hotelling's Trace	.000	.995
		Roy's Largest Root	.000	.995
Within Subjects	Prepost	Pillai's Trace	.	.
		Wilks' Lambda	.	.
		Hotelling's Trace	.	.
		Roy's Largest Root	.	.

a. Design: Intercept
Within Subjects Design: prepost
b. Exact statistic
c. Cannot produce multivariate test statistics because of insufficient residual degrees of freedom.

Tests of Within-Subjects Effects

Multivariate[a,b]

Within Subjects Effect		Value	F	Hypothesis df	Error df	Sig.
prepost	Pillai's Trace	.931	1.913	24.000	102.000	.014
	Wilks' Lambda	.277	2.168	24.000	93.411	.004
	Hotelling's Trace	1.916	2.448	24.000	92.000	.001
	Roy's Largest Root	1.519	6.455[c]	8.000	34.000	.000

Multivariate[a,b]

Within Subjects Effect		Partial Eta Squared
prepost	Pillai's Trace	.310
	Wilks' Lambda	.348
	Hotelling's Trace	.390
	Roy's Largest Root	.603

a. Design: Intercept
Within Subjects Design: prepost
b. Tests are based on averaged variables.
c. The statistic is an upper bound on F that yields a lower bound on the significance level.

Univariate Tests

Source	Measure		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
prepost	Q1	Sphericity Assumed	.643	3	.214	.374	.772	.028
		Greenhouse-Geisser	.643	2.760	.233	.374	.756	.028
		Huynh-Feldt	.643	3.000	.214	.374	.772	.028
		Lower-bound	.643	1.000	.643	.374	.551	.028
	Q2	Sphericity Assumed	1.482	3	.494	.811	.496	.059

		Greenhouse-Geisser	1.482	2.394	.619	.811	.473	.059
		Huynh-Feldt	1.482	2.971	.499	.811	.495	.059
		Lower-bound	1.482	1.000	1.482	.811	.384	.059
	Q3	Sphericity Assumed	3.000	3	1.000	1.322	.281	.092
		Greenhouse-Geisser	3.000	2.343	1.280	1.322	.284	.092
		Huynh-Feldt	3.000	2.891	1.038	1.322	.282	.092
		Lower-bound	3.000	1.000	3.000	1.322	.271	.092
	Q4	Sphericity Assumed	3.000	3	1.000	1.560	.214	.107
		Greenhouse-Geisser	3.000	2.272	1.321	1.560	.226	.107
		Huynh-Feldt	3.000	2.778	1.080	1.560	.218	.107
		Lower-bound	3.000	1.000	3.000	1.560	.234	.107
	Q5	Sphericity Assumed	8.339	3	2.780	5.888	.002	.312
		Greenhouse-Geisser	8.339	2.289	3.644	5.888	.005	.312
		Huynh-Feldt	8.339	2.805	2.973	5.888	.003	.312
		Lower-bound	8.339	1.000	8.339	5.888	.031	.312
	Q6	Sphericity Assumed	5.339	3	1.780	2.679	.060	.171
		Greenhouse-Geisser	5.339	2.009	2.658	2.679	.087	.171
		Huynh-Feldt	5.339	2.377	2.247	2.679	.076	.171
		Lower-bound	5.339	1.000	5.339	2.679	.126	.171
	Q7	Sphericity Assumed	5.000	3	1.667	2.955	.044	.185
		Greenhouse-Geisser	5.000	2.670	1.873	2.955	.051	.185
		Huynh-Feldt	5.000	3.000	1.667	2.955	.044	.185
		Lower-bound	5.000	1.000	5.000	2.955	.109	.185
	Q8	Sphericity Assumed	15.000	3	5.000	11.143	.000	.462
		Greenhouse-Geisser	15.000	2.415	6.212	11.143	.000	.462
		Huynh-Feldt	15.000	3.000	5.000	11.143	.000	.462
		Lower-bound	15.000	1.000	15.000	11.143	.005	.462
Error(prepost)	Q1	Sphericity Assumed	22.357	39	.573			
		Greenhouse-Geisser	22.357	35.875	.623			
		Huynh-Feldt	22.357	39.000	.573			
		Lower-bound	22.357	13.000	1.720			
	Q2	Sphericity Assumed	23.768	39	.609			
		Greenhouse-Geisser	23.768	31.120	.764			
		Huynh-Feldt	23.768	38.627	.615			
		Lower-bound	23.768	13.000	1.828			

	Q3	Sphericity Assumed	29.500	39	.756			
		Greenhouse-Geisser	29.500	30.462	.968			
		Huynh-Feldt	29.500	37.578	.785			
		Lower-bound	29.500	13.000	2.269			
	Q4	Sphericity Assumed	25.000	39	.641			
		Greenhouse-Geisser	25.000	29.530	.847			
		Huynh-Feldt	25.000	36.112	.692			
		Lower-bound	25.000	13.000	1.923			
	Q5	Sphericity Assumed	18.411	39	.472			
		Greenhouse-Geisser	18.411	29.753	.619			
		Huynh-Feldt	18.411	36.461	.505			
		Lower-bound	18.411	13.000	1.416			
	Q6	Sphericity Assumed	25.911	39	.664			
		Greenhouse-Geisser	25.911	26.114	.992			
		Huynh-Feldt	25.911	30.896	.839			
		Lower-bound	25.911	13.000	1.993			
	Q7	Sphericity Assumed	22.000	39	.564			
		Greenhouse-Geisser	22.000	34.708	.634			
		Huynh-Feldt	22.000	39.000	.564			
		Lower-bound	22.000	13.000	1.692			
	Q8	Sphericity Assumed	17.500	39	.449			
		Greenhouse-Geisser	17.500	31.393	.557			
		Huynh-Feldt	17.500	39.000	.449			
		Lower-bound	17.500	13.000	1.346			

Appendix O: Repeated measures MANOVA: Voice Activity and Participation (Objective 1B)

Descriptive Statistics

	Mean	Std. Deviation	N
C1V1	6.163	2.4193	16
C1V2	3.206	1.9972	16
C1V3	3.825	2.5738	16
C1V4	3.600	2.0839	16
C3V1	74.331	22.1931	16
C3V2	38.794	20.3316	16
C3V3	40.437	26.5979	16
C3V4	39.019	16.6424	16
C4V1	20.763	9.6216	16

C4V2	12.594	8.6238	16
C4V3	12.812	9.4837	16
C4V4	11.825	6.7076	16
C5V1	42.069	16.9579	16
C5V2	26.838	17.7184	16
C5V3	28.969	18.4350	16
C5V4	23.450	11.9413	16

Multivariate Tests[a]

Effect			Value	F	Hypothesis df	Error df
Between Subjects	Intercept	Pillai's Trace	.913	31.466[b]	4.000	12.000
		Wilks' Lambda	.087	31.466[b]	4.000	12.000
		Hotelling's Trace	10.489	31.466[b]	4.000	12.000
		Roy's Largest Root	10.489	31.466[b]	4.000	12.000
Within Subjects	prepost	Pillai's Trace	.876	2.350[b]	12.000	4.000
		Wilks' Lambda	.124	2.350[b]	12.000	4.000
		Hotelling's Trace	7.050	2.350[b]	12.000	4.000
		Roy's Largest Root	7.050	2.350[b]	12.000	4.000

Multivariate Tests[a]

Effect			Sig.	Partial Eta Squared
Between Subjects	Intercept	Pillai's Trace	.000	.913
		Wilks' Lambda	.000	.913
		Hotelling's Trace	.000	.913
		Roy's Largest Root	.000	.913
Within Subjects	Prepost	Pillai's Trace	.213	.876
		Wilks' Lambda	.213	.876
		Hotelling's Trace	.213	.876
		Roy's Largest Root	.213	.876

a. Design: Intercept
Within Subjects Design: prepost
b. Exact statistic

Tests of Within-Subjects Effects

Multivariate[a,b]

Within Subjects Effect		Value	F	Hypothesis df	Error df	Sig.
prepost	Pillai's Trace	.645	3.013	12.000	132.000	.001
	Wilks' Lambda	.398	3.865	12.000	111.413	.000
	Hotelling's Trace	1.405	4.761	12.000	122.000	.000
	Roy's Largest Root	1.327	14.592[c]	4.000	44.000	.000

Multivariate[a,b]

Within Subjects Effect		Partial Eta Squared
prepost	Pillai's Trace	.215
	Wilks' Lambda	.264
	Hotelling's Trace	.319
	Roy's Largest Root	.570

a. Design: Intercept
Within Subjects Design: prepost
b. Tests are based on averaged variables.

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

Univariate Tests

Source	Measure		Type III Sum of Squares	df	Mean Square	F	Sig.
prepost	C1	Sphericity Assumed	85.433	3	28.478	8.424	.000
		Greenhouse-Geisser	85.433	2.508	34.069	8.424	.000
		Huynh-Feldt	85.433	3.000	28.478	8.424	.000
		Lower-bound	85.433	1.000	85.433	8.424	.011
	C3	Sphericity Assumed	14653.753	3	4884.584	18.787	.000
		Greenhouse-Geisser	14653.753	2.563	5717.482	18.787	.000
		Huynh-Feldt	14653.753	3.000	4884.584	18.787	.000
		Lower-bound	14653.753	1.000	14653.753	18.787	.001
	C4	Sphericity Assumed	845.695	3	281.898	7.538	.000
		Greenhouse-Geisser	845.695	2.380	355.299	7.538	.001
		Huynh-Feldt	845.695	2.859	295.770	7.538	.000
		Lower-bound	845.695	1.000	845.695	7.538	.015
	C5	Sphericity Assumed	3186.931	3	1062.310	8.244	.000
		Greenhouse-Geisser	3186.931	2.542	1253.893	8.244	.000
		Huynh-Feldt	3186.931	3.000	1062.310	8.244	.000
		Lower-bound	3186.931	1.000	3186.931	8.244	.012
Error(prepost)	C1	Sphericity Assumed	152.125	45	3.381		
		Greenhouse-Geisser	152.125	37.615	4.044		
		Huynh-Feldt	152.125	45.000	3.381		
		Lower-bound	152.125	15.000	10.142		
	C3	Sphericity Assumed	11699.955	45	259.999		
		Greenhouse-Geisser	11699.955	38.445	304.333		
		Huynh-Feldt	11699.955	45.000	259.999		
		Lower-bound	11699.955	15.000	779.997		
	C4	Sphericity Assumed	1682.807	45	37.396		
		Greenhouse-Geisser	1682.807	35.704	47.133		
		Huynh-Feldt	1682.807	42.890	39.236		
		Lower-bound	1682.807	15.000	112.187		
	C5	Sphericity Assumed	5798.389	45	128.853		
		Greenhouse-Geisser	5798.389	38.124	152.091		
		Huynh-Feldt	5798.389	45.000	128.853		
		Lower-bound	5798.389	15.000	386.559		

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	C1	1128.120	1	1128.120	105.753	.000	.876
	C3	148350.151	1	148350.151	133.609	.000	.899
	C4	13453.100	1	13453.100	70.922	.000	.825
	C5	58879.023	1	58879.023	84.427	.000	.849
Error	C1	160.012	15	10.667			
	C3	16654.931	15	1110.329			
	C4	2845.347	15	189.690			
	C5	10460.958	15	697.397			

Appendix P: Repeated measures MANOVA: Communicative Effectiveness (Objective 2A)

Descriptive Statistics

	Mean	Std. Deviation	N
Q1CES2	3.14	.663	14
Q1CES3	3.14	.770	14
Q1CES4	3.21	.699	14
Q2CES2	2.79	.699	14
Q2CES3	2.86	.864	14
Q2CES4	2.71	.914	14
Q3CES2	2.64	.745	14
Q3CES3	2.86	.535	14
Q3CES4	2.21	1.051	14
Q4CES2	2.36	.633	14
Q4CES3	2.57	.514	14
Q4CES4	1.93	.997	14
Q5CES2	2.43	.852	14
Q5CES3	2.93	.616	14
Q5CES4	2.79	.579	14
Q6CES2	2.14	.949	14
Q6CES3	2.64	.929	14
Q6CES4	2.71	.611	14
Q7CES2	2.86	.663	14
Q7CES3	2.79	.802	14
Q7CES4	3.00	.784	14
Q8CES2	2.71	.825	14
Q8CES3	3.36	.842	14
Q8CES4	3.29	.469	14

Multivariate Tests[a]

Effect			Value	F	Hypothesis df	Error df
Between Subjects	Intercept	Pillai's Trace	.992	97.462[b]	8.000	6.000
		Wilks' Lambda	.008	97.462[b]	8.000	6.000
		Hotelling's Trace	129.950	97.462[b]	8.000	6.000
		Roy's Largest Root	129.950	97.462[b]	8.000	6.000
Within Subjects	Device	Pillai's Trace	.[c]	.	.	.
		Wilks' Lambda	.[c]	.	.	.
		Hotelling's Trace	.[c]	.	.	.
		Roy's Largest Root	.[c]	.	.	.

Multivariate Tests[a]

Effect			Sig.	Partial Eta Squared
Between Subjects	Intercept	Pillai's Trace	.000	.992
		Wilks' Lambda	.000	.992
		Hotelling's Trace	.000	.992
		Roy's Largest Root	.000	.992
Within Subjects	Device	Pillai's Trace	.	.
		Wilks' Lambda	.	.

	Hotelling's Trace	.	.
	Roy's Largest Root	.	.

a. Design: Intercept
Within Subjects Design: Device
b. Exact statistic
c. Cannot produce multivariate test statistics because of insufficient residual degrees of freedom.

Tests of Within-Subjects Effects

Multivariate[a,b]

Within Subjects Effect		Value	F	Hypothesis df	Error df	Sig.
Device	Pillai's Trace	.862	1.895	16.000	40.000	.051
	Wilks' Lambda	.307	1.910[c]	16.000	38.000	.051
	Hotelling's Trace	1.704	1.917	16.000	36.000	.052
	Roy's Largest Root	1.269	3.171[d]	8.000	20.000	.017

Multivariate[a,b]

Within Subjects Effect		Partial Eta Squared
Device	Pillai's Trace	.431
	Wilks' Lambda	.446
	Hotelling's Trace	.460
	Roy's Largest Root	.559

a. Design: Intercept
Within Subjects Design: Device
b. Tests are based on averaged variables.
c. Exact statistic
d. The statistic is an upper bound on F that yields a lower bound on the significance level.

Univariate Tests

Source	Measure		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Device	Q1	Sphericity Assumed	.048	2	.024	.047	.955	.004
		Greenhouse-Geisser	.048	1.906	.025	.047	.949	.004
		Huynh-Feldt	.048	2.000	.024	.047	.955	.004
		Lower-bound	.048	1.000	.048	.047	.832	.004
	Q2	Sphericity Assumed	.143	2	.071	.157	.856	.012
		Greenhouse-Geisser	.143	1.937	.074	.157	.849	.012
		Huynh-Feldt	.143	2.000	.071	.157	.856	.012
		Lower-bound	.143	1.000	.143	.157	.699	.012
	Q3	Sphericity Assumed	3.000	2	1.500	2.388	.112	.155
		Greenhouse-Geisser	3.000	1.357	2.211	2.388	.134	.155
		Huynh-Feldt	3.000	1.460	2.055	2.388	.130	.155
		Lower-bound	3.000	1.000	3.000	2.388	.146	.155
	Q4	Sphericity Assumed	3.000	2	1.500	3.545	.043	.214

		Greenhouse-Geisser	3.000	1.867	1.607	3.545	.047	.214
		Huynh-Feldt	3.000	2.000	1.500	3.545	.043	.214
		Lower-bound	3.000	1.000	3.000	3.545	.082	.214
	Q5	Sphericity Assumed	1.857	2	.929	2.965	.069	.186
		Greenhouse-Geisser	1.857	1.693	1.097	2.965	.080	.186
		Huynh-Feldt	1.857	1.919	.968	2.965	.072	.186
		Lower-bound	1.857	1.000	1.857	2.965	.109	.186
	Q6	Sphericity Assumed	2.714	2	1.357	2.796	.079	.177
		Greenhouse-Geisser	2.714	1.877	1.446	2.796	.084	.177
		Huynh-Feldt	2.714	2.000	1.357	2.796	.079	.177
		Lower-bound	2.714	1.000	2.714	2.796	.118	.177
	Q7	Sphericity Assumed	.333	2	.167	.351	.707	.026
		Greenhouse-Geisser	.333	1.802	.185	.351	.686	.026
		Huynh-Feldt	.333	2.000	.167	.351	.707	.026
		Lower-bound	.333	1.000	.333	.351	.564	.026
	Q8	Sphericity Assumed	3.476	2	1.738	5.302	.012	.290
		Greenhouse-Geisser	3.476	1.852	1.877	5.302	.014	.290
		Huynh-Feldt	3.476	2.000	1.738	5.302	.012	.290
		Lower-bound	3.476	1.000	3.476	5.302	.038	.290
Error(Device)	Q1	Sphericity Assumed	13.286	26	.511			
		Greenhouse-Geisser	13.286	24.779	.536			
		Huynh-Feldt	13.286	26.000	.511			
		Lower-bound	13.286	13.000	1.022			
	Q2	Sphericity Assumed	11.857	26	.456			
		Greenhouse-Geisser	11.857	25.178	.471			
		Huynh-Feldt	11.857	26.000	.456			
		Lower-bound	11.857	13.000	.912			
	Q3	Sphericity Assumed	16.333	26	.628			
		Greenhouse-Geisser	16.333	17.642	.926			
		Huynh-Feldt	16.333	18.980	.861			
		Lower-bound	16.333	13.000	1.256			
	Q4	Sphericity Assumed	11.000	26	.423			
		Greenhouse-Geisser	11.000	24.271	.453			
		Huynh-Feldt	11.000	26.000	.423			
		Lower-bound	11.000	13.000	.846			

	Q5	Sphericity Assumed	8.143	26	.313			
		Greenhouse-Geisser	8.143	22.010	.370			
		Huynh-Feldt	8.143	24.953	.326			
		Lower-bound	8.143	13.000	.626			
	Q6	Sphericity Assumed	12.619	26	.485			
		Greenhouse-Geisser	12.619	24.395	.517			
		Huynh-Feldt	12.619	26.000	.485			
		Lower-bound	12.619	13.000	.971			
	Q7	Sphericity Assumed	12.333	26	.474			
		Greenhouse-Geisser	12.333	23.430	.526			
		Huynh-Feldt	12.333	26.000	.474			
		Lower-bound	12.333	13.000	.949			
	Q8	Sphericity Assumed	8.524	26	.328			
		Greenhouse-Geisser	8.524	24.078	.354			
		Huynh-Feldt	8.524	26.000	.328			
		Lower-bound	8.524	13.000	.656			

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	Q1	421.167	1	421.167	842.333	.000	.985
	Q2	325.929	1	325.929	281.133	.000	.956
	Q3	277.714	1	277.714	403.277	.000	.969
	Q4	219.429	1	219.429	269.838	.000	.954
	Q5	309.429	1	309.429	380.514	.000	.967
	Q6	262.500	1	262.500	225.000	.000	.945
	Q7	348.595	1	348.595	465.362	.000	.973
	Q8	408.595	1	408.595	428.202	.000	.971
Error	Q1	6.500	13	.500			
	Q2	15.071	13	1.159			
	Q3	8.952	13	.689			
	Q4	10.571	13	.813			
	Q5	10.571	13	.813			
	Q6	15.167	13	1.167			
	Q7	9.738	13	.749			
	Q8	12.405	13	.954			

Appendix Q: Repeated measures MANOVA: Voice activity and participation (Objective 2B)

Descriptive Statistics

	Mean	Std. Deviation	N
C1V2	3.206	1.9972	16
C1V3	3.825	2.5738	16
C1V4	3.600	2.0839	16
C3V2	38.794	20.3316	16
C3V3	40.437	26.5979	16
C3V4	39.019	16.6424	16
C4V2	12.594	8.6238	16
C4V3	12.812	9.4837	16
C4V4	11.825	6.7076	16
C5V2	26.838	17.7184	16
C5V3	28.969	18.4350	16
C5V4	23.450	11.9413	16

Multivariate Tests[a]

Effect			Value	F	Hypothesis df	Error df
Between Subjects	Intercept	Pillai's Trace	.880	21.953[b]	4.000	12.000
		Wilks' Lambda	.120	21.953[b]	4.000	12.000
		Hotelling's Trace	7.318	21.953[b]	4.000	12.000
		Roy's Largest Root	7.318	21.953[b]	4.000	12.000
Within Subjects	Device	Pillai's Trace	.410	.694[b]	8.000	8.000
		Wilks' Lambda	.590	.694[b]	8.000	8.000
		Hotelling's Trace	.694	.694[b]	8.000	8.000
		Roy's Largest Root	.694	.694[b]	8.000	8.000

Multivariate Tests[a]

Effect			Sig.	Partial Eta Squared
Between Subjects	Intercept	Pillai's Trace	.000	.880
		Wilks' Lambda	.000	.880
		Hotelling's Trace	.000	.880
		Roy's Largest Root	.000	.880
Within Subjects	Device	Pillai's Trace	.692	.410
		Wilks' Lambda	.692	.410
		Hotelling's Trace	.692	.410
		Roy's Largest Root	.692	.410

a. Design: Intercept
Within Subjects Design: Device
b. Exact statistic

Tests of Within-Subjects Effects

Multivariate[a,b]

Within Subjects Effect		Value	F	Hypothesis df	Error df	Sig.
Device	Pillai's Trace	.132	.493	8.000	56.000	.856
	Wilks' Lambda	.872	.480[c]	8.000	54.000	.865
	Hotelling's Trace	.144	.467	8.000	52.000	.874
	Roy's Largest Root	.111	.776[d]	4.000	28.000	.550

Multivariate[a,b]

Within Subjects Effect		Partial Eta Squared
Device	Pillai's Trace	.066
	Wilks' Lambda	.066
	Hotelling's Trace	.067
	Roy's Largest Root	.100

a. Design: Intercept
Within Subjects Design: Device
b. Tests are based on averaged variables.
c. Exact statistic
d. The statistic is an upper bound on F that yields a lower bound on the significance level.

Univariate Tests

Source	Measure		Type III Sum of Squares	df	Mean Square	F	Sig.
Device	C1	Sphericity Assumed	3.139	2	1.569	.424	.659
		Greenhouse-Geisser	3.139	1.883	1.667	.424	.647
		Huynh-Feldt	3.139	2.000	1.569	.424	.659
		Lower-bound	3.139	1.000	3.139	.424	.525
	C3	Sphericity Assumed	25.415	2	12.708	.056	.945
		Greenhouse-Geisser	25.415	1.704	14.913	.056	.923
		Huynh-Feldt	25.415	1.900	13.374	.056	.939
		Lower-bound	25.415	1.000	25.415	.056	.816
	C4	Sphericity Assumed	8.608	2	4.304	.151	.861
		Greenhouse-Geisser	8.608	1.617	5.324	.151	.817
		Huynh-Feldt	8.608	1.783	4.827	.151	.838
		Lower-bound	8.608	1.000	8.608	.151	.703
	C5	Sphericity Assumed	247.861	2	123.931	1.072	.355
		Greenhouse-Geisser	247.861	1.987	124.756	1.072	.355
		Huynh-Feldt	247.861	2.000	123.931	1.072	.355
		Lower-bound	247.861	1.000	247.861	1.072	.317
Error(Device)	C1	Sphericity Assumed	111.135	30	3.704		
		Greenhouse-Geisser	111.135	28.238	3.936		
		Huynh-Feldt	111.135	30.000	3.704		
		Lower-bound	111.135	15.000	7.409		
	C3	Sphericity Assumed	6770.305	30	225.677		
		Greenhouse-Geisser	6770.305	25.563	264.847		
		Huynh-Feldt	6770.305	28.506	237.505		
		Lower-bound	6770.305	15.000	451.354		
	C4	Sphericity Assumed	856.139	30	28.538		
		Greenhouse-Geisser	856.139	24.251	35.303		
		Huynh-Feldt	856.139	26.751	32.004		
		Lower-bound	856.139	15.000	57.076		
	C5	Sphericity Assumed	3467.472	30	115.582		
		Greenhouse-Geisser	3467.472	29.802	116.352		
		Huynh-Feldt	3467.472	30.000	115.582		
		Lower-bound	3467.472	15.000	231.165		

Univariate Tests

Source	Measure		Partial Eta Squared
Device	C1	Sphericity Assumed	.027
		Greenhouse-Geisser	.027
		Huynh-Feldt	.027
		Lower-bound	.027
	C3	Sphericity Assumed	.004
		Greenhouse-Geisser	.004
		Huynh-Feldt	.004
		Lower-bound	.004
	C4	Sphericity Assumed	.010
		Greenhouse-Geisser	.010
		Huynh-Feldt	.010
		Lower-bound	.010
	C5	Sphericity Assumed	.067
		Greenhouse-Geisser	.067
		Huynh-Feldt	.067
		Lower-bound	.067
Error(Device)	C1	Sphericity Assumed	
		Greenhouse-Geisser	
		Huynh-Feldt	
		Lower-bound	
	C3	Sphericity Assumed	
		Greenhouse-Geisser	
		Huynh-Feldt	
		Lower-bound	
	C4	Sphericity Assumed	
		Greenhouse-Geisser	
		Huynh-Feldt	
		Lower-bound	
	C5	Sphericity Assumed	
		Greenhouse-Geisser	
		Huynh-Feldt	
		Lower-bound	

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	C1	602.792	1	602.792	79.872	.000	.842
	C3	74576.333	1	74576.333	78.797	.000	.840
	C4	7392.885	1	7392.885	48.565	.000	.764
	C5	33501.617	1	33501.617	59.272	.000	.798
Error	C1	113.205	15	7.547			
	C3	14196.587	15	946.439			
	C4	2283.378	15	152.225			
	C5	8478.320	15	565.221			

Appendix R: Two-factor repeated measures MANOVA: Communicative effectiveness, HP participants versus PCP participants (Objective 3A)

Between-Subjects Factors

		N
Group	1.00	14
	2.00	16

Descriptive Statistics

	Group	Mean	Std. Deviation	N
Q1CES0	1.00	2.9286	.73005	14
	2.00	2.6250	.88506	16
	Total	2.7667	.81720	30
Q1CES1	1.00	3.1429	.66299	14
	2.00	2.9375	.77190	16
	Total	3.0333	.71840	30
Q1CES2	1.00	3.1429	.77033	14
	2.00	3.4375	.62915	16
	Total	3.3000	.70221	30
Q1CES3	1.00	3.2143	.69929	14
	2.00	3.4375	.72744	16
	Total	3.3333	.71116	30
Q2CES0	1.00	2.4286	.93761	14
	2.00	2.4375	.81394	16
	Total	2.4333	.85836	30
Q2CES1	1.00	2.7857	.69929	14
	2.00	2.8125	.75000	16
	Total	2.8000	.71438	30
Q2CES2	1.00	2.8571	.86444	14
	2.00	3.1875	.75000	16
	Total	3.0333	.80872	30
Q2CES3	1.00	2.7143	.91387	14
	2.00	3.0000	.96609	16
	Total	2.8667	.93710	30
Q3CES0	1.00	2.5714	.93761	14
	2.00	2.3750	.71880	16
	Total	2.4667	.81931	30
Q3CES1	1.00	2.6429	.74495	14
	2.00	2.5625	1.03078	16
	Total	2.6000	.89443	30
Q3CES2	1.00	2.8571	.53452	14
	2.00	2.8125	.75000	16
	Total	2.8333	.64772	30
Q3CES3	1.00	2.2143	1.05090	14
	2.00	2.4375	1.09354	16
	Total	2.3333	1.06134	30
Q4CES0	1.00	2.2857	1.13873	14
	2.00	1.7500	.68313	16
	Total	2.0000	.94686	30
Q4CES1	1.00	2.3571	.63332	14
	2.00	2.3750	1.02470	16

	Total	2.3667	.85029	30
Q4CES2	1.00	2.5714	.51355	14
	2.00	2.6875	.79320	16
	Total	2.6333	.66868	30
Q4CES3	1.00	1.9286	.99725	14
	2.00	2.1250	1.20416	16
	Total	2.0333	1.09807	30
Q5CES0	1.00	1.9286	.91687	14
	2.00	1.5625	.62915	16
	Total	1.7333	.78492	30
Q5CES1	1.00	2.4286	.85163	14
	2.00	2.8125	.75000	16
	Total	2.6333	.80872	30
Q5CES2	1.00	2.9286	.61573	14
	2.00	2.8125	.75000	16
	Total	2.8667	.68145	30
Q5CES3	1.00	2.7857	.57893	14
	2.00	2.4375	1.09354	16
	Total	2.6000	.89443	30
Q6CES0	1.00	2.0000	.87706	14
	2.00	1.9375	.68007	16
	Total	1.9667	.76489	30
Q6CES1	1.00	2.1429	.94926	14
	2.00	2.4375	.81394	16
	Total	2.3000	.87691	30
Q6CES2	1.00	2.6429	.92878	14
	2.00	2.6250	.71880	16
	Total	2.6333	.80872	30
Q6CES3	1.00	2.7143	.61125	14
	2.00	2.6250	.88506	16
	Total	2.6667	.75810	30
Q7CES0	1.00	2.2143	.97496	14
	2.00	2.3750	.88506	16
	Total	2.3000	.91539	30
Q7CES1	1.00	2.8571	.66299	14
	2.00	3.0000	1.03280	16
	Total	2.9333	.86834	30
Q7CES2	1.00	2.7857	.80178	14
	2.00	2.8125	.65511	16
	Total	2.8000	.71438	30
Q7CES3	1.00	3.0000	.78446	14
	2.00	3.3125	.70415	16
	Total	3.1667	.74664	30
Q8CES0	1.00	2.0714	.91687	14
	2.00	1.7500	.68313	16
	Total	1.9000	.80301	30
Q8CES1	1.00	2.7143	.82542	14
	2.00	3.3125	.70415	16
	Total	3.0333	.80872	30
Q8CES2	1.00	3.3571	.84190	14
	2.00	3.5000	.51640	16

	Total	3.4333	.67891	30
Q8CES3	1.00	3.2857	.46881	14
	2.00	3.5000	.63246	16
	Total	3.4000	.56324	30

Multivariate Tests[a]

Effect			Value	F	Hypothesis df
Between Subjects	Intercept	Pillai's Trace	.993	399.785[b]	8.000
		Wilks' Lambda	.007	399.785[b]	8.000
		Hotelling's Trace	152.299	399.785[b]	8.000
		Roy's Largest Root	152.299	399.785[b]	8.000
	Group	Pillai's Trace	.257	.910[b]	8.000
		Wilks' Lambda	.743	.910[b]	8.000
		Hotelling's Trace	.347	.910[b]	8.000
		Roy's Largest Root	.347	.910[b]	8.000
Within Subjects	prepost	Pillai's Trace	.964	5.593[b]	24.000
		Wilks' Lambda	.036	5.593[b]	24.000
		Hotelling's Trace	26.849	5.593[b]	24.000
		Roy's Largest Root	26.849	5.593[b]	24.000
	prepost * Group	Pillai's Trace	.864	1.327[b]	24.000
		Wilks' Lambda	.136	1.327[b]	24.000
		Hotelling's Trace	6.368	1.327[b]	24.000
		Roy's Largest Root	6.368	1.327[b]	24.000

Multivariate Tests[a]

Effect			Error df	Sig.	Partial Eta Squared
Between Subjects	Intercept	Pillai's Trace	21.000	.000	.993
		Wilks' Lambda	21.000	.000	.993
		Hotelling's Trace	21.000	.000	.993
		Roy's Largest Root	21.000	.000	.993
	Group	Pillai's Trace	21.000	.527	.257
		Wilks' Lambda	21.000	.527	.257
		Hotelling's Trace	21.000	.527	.257
		Roy's Largest Root	21.000	.527	.257
Within Subjects	prepost	Pillai's Trace	5.000	.032	.964
		Wilks' Lambda	5.000	.032	.964
		Hotelling's Trace	5.000	.032	.964
		Roy's Largest Root	5.000	.032	.964
	prepost * Group	Pillai's Trace	5.000	.408	.864
		Wilks' Lambda	5.000	.408	.864
		Hotelling's Trace	5.000	.408	.864
		Roy's Largest Root	5.000	.408	.864

a. Design: Intercept + Group
Within Subjects Design: prepost
b. Exact statistic

Tests of Within-Subjects Effects

Multivariate[a,b]

Within Subjects Effect		Value	F	Hypothesis df	Error df	Sig.
prepost	Pillai's Trace	.903	4.251	24.000	237.000	.000

	Wilks' Lambda	.279	5.152	24.000	223.925	.000
	Hotelling's Trace	1.961	6.182	24.000	227.000	.000
	Roy's Largest Root	1.610	15.903[c]	8.000	79.000	.000
prepost * Group	Pillai's Trace	.346	1.285	24.000	237.000	.174
	Wilks' Lambda	.687	1.290	24.000	223.925	.172
	Hotelling's Trace	.410	1.292	24.000	227.000	.171
	Roy's Largest Root	.226	2.229[c]	8.000	79.000	.034

Multivariate[a,b]

Within Subjects Effect		Partial Eta Squared
prepost	Pillai's Trace	.301
	Wilks' Lambda	.346
	Hotelling's Trace	.395
	Roy's Largest Root	.617
prepost * Group	Pillai's Trace	.115
	Wilks' Lambda	.118
	Hotelling's Trace	.120
	Roy's Largest Root	.184

a. Design: Intercept + Group
Within Subjects Design: prepost
b. Tests are based on averaged variables.
c. The statistic is an upper bound on F that yields a lower bound on the significance level.

Univariate Tests

Source	Measure		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
prepost	Q1	Sphericity Assumed	5.823	3	1.941	3.298	.024	.105
		Greenhouse-Geisser	5.823	2.623	2.220	3.298	.030	.105
		Huynh-Feldt	5.823	3.000	1.941	3.298	.024	.105
		Lower-bound	5.823	1.000	5.823	3.298	.080	.105
	Q2	Sphericity Assumed	5.537	3	1.846	3.191	.028	.102
		Greenhouse-Geisser	5.537	2.370	2.336	3.191	.040	.102
		Huynh-Feldt	5.537	2.696	2.054	3.191	.033	.102
		Lower-bound	5.537	1.000	5.537	3.191	.085	.102
	Q3	Sphericity Assumed	4.172	3	1.391	2.016	.118	.067
		Greenhouse-Geisser	4.172	2.638	1.581	2.016	.127	.067
		Huynh-Feldt	4.172	3.000	1.391	2.016	.118	.067
		Lower-bound	4.172	1.000	4.172	2.016	.167	.067
	Q4	Sphericity Assumed	7.789	3	2.596	4.259	.008	.132
		Greenhouse-Geisser	7.789	2.480	3.141	4.259	.012	.132
		Huynh-Feldt	7.789	2.837	2.746	4.259	.009	.132
		Lower-bound	7.789	1.000	7.789	4.259	.048	.132

	Q5	Sphericity Assumed	21.735	3	7.245	13.166	.000	.320
		Greenhouse-Geisser	21.735	2.721	7.989	13.166	.000	.320
		Huynh-Feldt	21.735	3.000	7.245	13.166	.000	.320
		Lower-bound	21.735	1.000	21.735	13.166	.001	.320
	Q6	Sphericity Assumed	9.710	3	3.237	5.866	.001	.173
		Greenhouse-Geisser	9.710	2.613	3.716	5.866	.002	.173
		Huynh-Feldt	9.710	3.000	3.237	5.866	.001	.173
		Lower-bound	9.710	1.000	9.710	5.866	.022	.173
	Q7	Sphericity Assumed	11.908	3	3.969	6.586	.000	.190
		Greenhouse-Geisser	11.908	2.773	4.295	6.586	.001	.190
		Huynh-Feldt	11.908	3.000	3.969	6.586	.000	.190
		Lower-bound	11.908	1.000	11.908	6.586	.016	.190
	Q8	Sphericity Assumed	45.055	3	15.018	34.372	.000	.551
		Greenhouse-Geisser	45.055	2.720	16.562	34.372	.000	.551
		Huynh-Feldt	45.055	3.000	15.018	34.372	.000	.551
		Lower-bound	45.055	1.000	45.055	34.372	.000	.551
prepost * Group	Q1	Sphericity Assumed	2.023	3	.674	1.146	.335	.039
		Greenhouse-Geisser	2.023	2.623	.771	1.146	.333	.039
		Huynh-Feldt	2.023	3.000	.674	1.146	.335	.039
		Lower-bound	2.023	1.000	2.023	1.146	.294	.039
	Q2	Sphericity Assumed	.637	3	.212	.367	.777	.013
		Greenhouse-Geisser	.637	2.370	.269	.367	.729	.013
		Huynh-Feldt	.637	2.696	.236	.367	.756	.013
		Lower-bound	.637	1.000	.637	.367	.549	.013
	Q3	Sphericity Assumed	.705	3	.235	.341	.796	.012
		Greenhouse-Geisser	.705	2.638	.267	.341	.770	.012
		Huynh-Feldt	.705	3.000	.235	.341	.796	.012
		Lower-bound	.705	1.000	.705	.341	.564	.012
	Q4	Sphericity Assumed	2.455	3	.818	1.343	.266	.046
		Greenhouse-Geisser	2.455	2.480	.990	1.343	.269	.046
		Huynh-Feldt	2.455	2.837	.865	1.343	.267	.046
		Lower-bound	2.455	1.000	2.455	1.343	.256	.046
	Q5	Sphericity Assumed	2.735	3	.912	1.657	.183	.056
		Greenhouse-Geisser	2.735	2.721	1.005	1.657	.188	.056
		Huynh-Feldt	2.735	3.000	.912	1.657	.183	.056

		Lower-bound	2.735	1.000	2.735	1.657	.209	.056
	Q6	Sphericity Assumed	.710	3	.237	.429	.733	.015
		Greenhouse-Geisser	.710	2.613	.272	.429	.706	.015
		Huynh-Feldt	.710	3.000	.237	.429	.733	.015
		Lower-bound	.710	1.000	.710	.429	.518	.015
	Q7	Sphericity Assumed	.308	3	.103	.171	.916	.006
		Greenhouse-Geisser	.308	2.773	.111	.171	.904	.006
		Huynh-Feldt	.308	3.000	.103	.171	.916	.006
		Lower-bound	.308	1.000	.308	.171	.683	.006
	Q8	Sphericity Assumed	3.189	3	1.063	2.432	.071	.080
		Greenhouse-Geisser	3.189	2.720	1.172	2.432	.077	.080
		Huynh-Feldt	3.189	3.000	1.063	2.432	.071	.080
		Lower-bound	3.189	1.000	3.189	2.432	.130	.080
Error(prepost)	Q1	Sphericity Assumed	49.435	84	.589			
		Greenhouse-Geisser	49.435	73.442	.673			
		Huynh-Feldt	49.435	84.000	.589			
		Lower-bound	49.435	28.000	1.766			
	Q2	Sphericity Assumed	48.596	84	.579			
		Greenhouse-Geisser	48.596	66.365	.732			
		Huynh-Feldt	48.596	75.496	.644			
		Lower-bound	48.596	28.000	1.736			
	Q3	Sphericity Assumed	57.953	84	.690			
		Greenhouse-Geisser	57.953	73.870	.785			
		Huynh-Feldt	57.953	84.000	.690			
		Lower-bound	57.953	28.000	2.070			
	Q4	Sphericity Assumed	51.203	84	.610			
		Greenhouse-Geisser	51.203	69.436	.737			
		Huynh-Feldt	51.203	79.430	.645			
		Lower-bound	51.203	28.000	1.829			
	Q5	Sphericity Assumed	46.223	84	.550			
		Greenhouse-Geisser	46.223	76.182	.607			
		Huynh-Feldt	46.223	84.000	.550			
		Lower-bound	46.223	28.000	1.651			
	Q6	Sphericity Assumed	46.348	84	.552			
		Greenhouse-Geisser	46.348	73.168	.633			

		Huynh-Feldt	46.348	84.000	.552			
		Lower-bound	46.348	28.000	1.655			
	Q7	Sphericity Assumed	50.625	84	.603			
		Greenhouse-Geisser	50.625	77.634	.652			
		Huynh-Feldt	50.625	84.000	.603			
		Lower-bound	50.625	28.000	1.808			
	Q8	Sphericity Assumed	36.703	84	.437			
		Greenhouse-Geisser	36.703	76.173	.482			
		Huynh-Feldt	36.703	84.000	.437			
		Lower-bound	36.703	28.000	1.311			

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Q1	1154.200	1	1154.200	2729.178	.000
	Q2	921.893	1	921.893	844.289	.000
	Q3	782.418	1	782.418	760.060	.000
	Q4	610.212	1	610.212	415.081	.000
	Q5	724.172	1	724.172	838.937	.000
	Q6	682.762	1	682.762	687.365	.000
	Q7	933.038	1	933.038	1027.390	.000
	Q8	1030.083	1	1030.083	1472.185	.000
Group	Q1	.000	1	.000	.000	.985
	Q2	.793	1	.793	.726	.401
	Q3	.018	1	.018	.017	.896
	Q4	.079	1	.079	.054	.819
	Q5	.372	1	.372	.431	.517
	Q6	.029	1	.029	.029	.865
	Q7	.771	1	.771	.849	.365
	Q8	.750	1	.750	1.072	.309
Error	Q1	11.842	28	.423		
	Q2	30.574	28	1.092		
	Q3	28.824	28	1.029		
	Q4	41.163	28	1.470		
	Q5	24.170	28	.863		
	Q6	27.813	28	.993		
	Q7	25.429	28	.908		
	Q8	19.592	28	.700		

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Measure	Partial Eta Squared
Intercept	Q1	.990
	Q2	.968
	Q3	.964
	Q4	.937
	Q5	.968

	Q6	.961
	Q7	.973
	Q8	.981
Group	Q1	.000
	Q2	.025
	Q3	.001
	Q4	.002
	Q5	.015
	Q6	.001
	Q7	.029
	Q8	.037
Error	Q1	
	Q2	
	Q3	
	Q4	
	Q5	
	Q6	
	Q7	
	Q8	

Appendix S: Two-factor repeated measures MANOVA: Voice activity and participation, HP participants versus PCP participants (Objective 3B)

Between-Subjects Factors

		N
Group	1	16
	2	16

Descriptive Statistics

	Group	Mean	Std. Deviation	N
C1VAPP0	1	6.163	2.4193	16
	2	10.200	19.0059	16
	Total	8.181	13.4843	32
C1VAPP1	1	3.206	1.9972	16
	2	3.981	2.1806	16
	Total	3.594	2.0942	32
C1VAPP2	1	3.825	2.5738	16
	2	3.581	2.6529	16
	Total	3.703	2.5741	32
C1VAPP3	1	3.600	2.0839	16
	2	3.175	2.0869	16
	Total	3.387	2.0628	32
C3VAPP0	1	74.331	22.1931	16
	2	76.256	22.8716	16
	Total	75.294	22.1900	32
C3VAPP1	1	38.794	20.3316	16
	2	47.125	24.1703	16
	Total	42.959	22.3743	32
C3VAPP2	1	40.437	26.5979	16
	2	37.131	22.2379	16
	Total	38.784	24.1748	32
C3VAPP3	1	39.0188	16.64244	16
	2	48.2063	26.25822	16
	Total	43.6125	22.12301	32
C4VAPP0	1	20.763	9.6216	16
	2	21.369	7.5176	16
	Total	21.066	8.4991	32
C4VAPP1	1	12.594	8.6238	16
	2	13.631	8.8304	16
	Total	13.112	8.6019	32
C4VAPP2	1	12.812	9.4837	16
	2	12.325	7.4901	16
	Total	12.569	8.4099	32
C4VAPP3	1	11.825	6.7076	16
	2	15.431	8.8252	16
	Total	13.628	7.9254	32
C5VAPP0	1	42.069	16.9579	16
	2	40.938	12.3958	16
	Total	41.503	14.6228	32
C5VAPP1	1	26.838	17.7184	16
	2	34.119	21.9792	16

	Total	30.478	19.9835	32
C5VAPP2	1	28.969	18.4350	16
	2	28.794	16.7764	16
	Total	28.881	17.3389	32
C5VAPP3	1	23.450	11.9413	16
	2	30.425	17.0993	16
	Total	26.938	14.9342	32

Multivariate Tests[a]

Effect			Value	F	Hypothesis df
Between Subjects	Intercept	Pillai's Trace	.902	62.240[b]	4.000
		Wilks' Lambda	.098	62.240[b]	4.000
		Hotelling's Trace	9.221	62.240[b]	4.000
		Roy's Largest Root	9.221	62.240[b]	4.000
	Group	Pillai's Trace	.031	.215[b]	4.000
		Wilks' Lambda	.969	.215[b]	4.000
		Hotelling's Trace	.032	.215[b]	4.000
		Roy's Largest Root	.032	.215[b]	4.000
Within Subjects	prepost	Pillai's Trace	.805	6.533[b]	12.000
		Wilks' Lambda	.195	6.533[b]	12.000
		Hotelling's Trace	4.126	6.533[b]	12.000
		Roy's Largest Root	4.126	6.533[b]	12.000
	prepost * Group	Pillai's Trace	.396	1.038[b]	12.000
		Wilks' Lambda	.604	1.038[b]	12.000
		Hotelling's Trace	.656	1.038[b]	12.000
		Roy's Largest Root	.656	1.038[b]	12.000

Multivariate Tests[a]

Effect			Error df	Sig.	Partial Eta Squared
Between Subjects	Intercept	Pillai's Trace	27.000	.000	.902
		Wilks' Lambda	27.000	.000	.902
		Hotelling's Trace	27.000	.000	.902
		Roy's Largest Root	27.000	.000	.902
	Group	Pillai's Trace	27.000	.928	.031
		Wilks' Lambda	27.000	.928	.031
		Hotelling's Trace	27.000	.928	.031
		Roy's Largest Root	27.000	.928	.031
Within Subjects	prepost	Pillai's Trace	19.000	.000	.805
		Wilks' Lambda	19.000	.000	.805
		Hotelling's Trace	19.000	.000	.805
		Roy's Largest Root	19.000	.000	.805
	prepost * Group	Pillai's Trace	19.000	.456	.396
		Wilks' Lambda	19.000	.456	.396
		Hotelling's Trace	19.000	.456	.396
		Roy's Largest Root	19.000	.456	.396

a. Design: Intercept + Group
Within Subjects Design: prepost
b. Exact statistic

Tests of Within-Subjects Effects

Multivariate[a,b]

Within Subjects Effect		Value	F	Hypothesis df	Error df	Sig.
prepost	Pillai's Trace	.594	5.492	12.000	267.000	.000
	Wilks' Lambda	.427	7.294	12.000	230.472	.000
	Hotelling's Trace	1.296	9.250	12.000	257.000	.000
	Roy's Largest Root	1.258	27.984[c]	4.000	89.000	.000
prepost * Group	Pillai's Trace	.087	.664	12.000	267.000	.785
	Wilks' Lambda	.915	.655	12.000	230.472	.794
	Hotelling's Trace	.090	.646	12.000	257.000	.802
	Roy's Largest Root	.054	1.200[c]	4.000	89.000	.317

Multivariate[a,b]

Within Subjects Effect		Partial Eta Squared
prepost	Pillai's Trace	.198
	Wilks' Lambda	.247
	Hotelling's Trace	.302
	Roy's Largest Root	.557
prepost * Group	Pillai's Trace	.029
	Wilks' Lambda	.029
	Hotelling's Trace	.029
	Roy's Largest Root	.051

a. Design: Intercept + Group
Within Subjects Design: prepost
b. Tests are based on averaged variables.
c. The statistic is an upper bound on F that yields a lower bound on the significance level.

Univariate Tests

Source	Measure		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
prepost	C1	Sphericity Assumed	513.863	3	171.288	3.750	.014	.111
		Greenhouse-Geisser	513.863	1.108	463.900	3.750	.058	.111
		Huynh-Feldt	513.863	1.158	443.893	3.750	.055	.111
		Lower-bound	513.863	1.000	513.863	3.750	.062	.111
	C3	Sphericity Assumed	27386.527	3	9128.842	34.791	.000	.537
		Greenhouse-Geisser	27386.527	2.651	10331.343	34.791	.000	.537
		Huynh-Feldt	27386.527	3.000	9128.842	34.791	.000	.537
		Lower-bound	27386.527	1.000	27386.527	34.791	.000	.537
	C4	Sphericity Assumed	1539.594	3	513.198	15.118	.000	.335
		Greenhouse-Geisser	1539.594	2.727	564.648	15.118	.000	.335
		Huynh-Feldt	1539.594	3.000	513.198	15.118	.000	.335
		Lower-bound	1539.594	1.000	1539.594	15.118	.001	.335
	C5	Sphericity Assumed	4095.072	3	1365.024	8.862	.000	.228

		Greenhouse-Geisser	4095.072	2.639	1551.989	8.862	.000	.228
		Huynh-Feldt	4095.072	3.000	1365.024	8.862	.000	.228
		Lower-bound	4095.072	1.000	4095.072	8.862	.006	.228
prepost * Group	C1	Sphericity Assumed	102.795	3	34.265	.750	.525	.024
		Greenhouse-Geisser	102.795	1.108	92.800	.750	.406	.024
		Huynh-Feldt	102.795	1.158	88.798	.750	.411	.024
		Lower-bound	102.795	1.000	102.795	.750	.393	.024
	C3	Sphericity Assumed	826.817	3	275.606	1.050	.374	.034
		Greenhouse-Geisser	826.817	2.651	311.910	1.050	.369	.034
		Huynh-Feldt	826.817	3.000	275.606	1.050	.374	.034
		Lower-bound	826.817	1.000	826.817	1.050	.314	.034
	C4	Sphericity Assumed	72.130	3	24.043	.708	.550	.023
		Greenhouse-Geisser	72.130	2.727	26.454	.708	.537	.023
		Huynh-Feldt	72.130	3.000	24.043	.708	.550	.023
		Lower-bound	72.130	1.000	72.130	.708	.407	.023
	C5	Sphericity Assumed	488.416	3	162.805	1.057	.372	.034
		Greenhouse-Geisser	488.416	2.639	185.104	1.057	.366	.034
		Huynh-Feldt	488.416	3.000	162.805	1.057	.372	.034
		Lower-bound	488.416	1.000	488.416	1.057	.312	.034
Error(prepost)	C1	Sphericity Assumed	4111.424	90	45.682			
		Greenhouse-Geisser	4111.424	33.231	123.722			
		Huynh-Feldt	4111.424	34.729	118.386			
		Lower-bound	4111.424	30.000	137.047			
	C3	Sphericity Assumed	23615.252	90	262.392			
		Greenhouse-Geisser	23615.252	79.525	296.955			
		Huynh-Feldt	23615.252	90.000	262.392			
		Lower-bound	23615.252	30.000	787.175			
	C4	Sphericity Assumed	3055.150	90	33.946			
		Greenhouse-Geisser	3055.150	81.799	37.349			
		Huynh-Feldt	3055.150	90.000	33.946			
		Lower-bound	3055.150	30.000	101.838			
	C5	Sphericity Assumed	13863.088	90	154.034			
		Greenhouse-Geisser	13863.088	79.158	175.132			
		Huynh-Feldt	13863.088	90.000	154.034			
		Lower-bound	13863.088	30.000	462.103			

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	C1	2847.294	1	2847.294	45.892	.000	.605
	C3	322083.380	1	322083.380	247.062	.000	.892
	C4	29161.125	1	29161.125	159.057	.000	.841
	C5	130662.720	1	130662.720	190.704	.000	.864
Group	C1	34.341	1	34.341	.554	.463	.018
	C3	520.838	1	520.838	.400	.532	.013
	C4	45.363	1	45.363	.247	.623	.008
	C5	335.405	1	335.405	.490	.490	.016
Error	C1	1861.312	30	62.044			
	C3	39109.607	30	1303.654			
	C4	5500.137	30	183.338			
	C5	20554.840	30	685.161			

Appendix T: Two-factor repeated measures MANOVA: Communicative effectiveness, Selectors versus Non-selectors (Objective 5A)

Between-Subjects Factors

		N
Selectors	1	10
	2	4

Descriptive Statistics

	Selectors	Mean	Std. Deviation	N
Q1CES0	1	2.90	.738	10
	2	3.00	.816	4
	Total	2.93	.730	14
Q1CES1	1	3.20	.632	10
	2	3.00	.816	4
	Total	3.14	.663	14
Q1CES2	1	3.00	.816	10
	2	3.50	.577	4
	Total	3.14	.770	14
Q1CES3	1	3.10	.738	10
	2	3.50	.577	4
	Total	3.21	.699	14
Q2CES0	1	2.40	.843	10
	2	2.50	1.291	4
	Total	2.43	.938	14
Q2CES1	1	2.70	.675	10
	2	3.00	.816	4
	Total	2.79	.699	14
Q2CES2	1	2.70	.949	10
	2	3.25	.500	4
	Total	2.86	.864	14
Q2CES3	1	2.50	.850	10
	2	3.25	.957	4
	Total	2.71	.914	14
Q3CES0	1	2.40	.966	10

	2	3.00	.816	4
	Total	2.57	.938	14
Q3CES1	1	2.70	.823	10
	2	2.50	.577	4
	Total	2.64	.745	14
Q3CES2	1	2.70	.483	10
	2	3.25	.500	4
	Total	2.86	.535	14
Q3CES3	1	1.70	.675	10
	2	3.50	.577	4
	Total	2.21	1.051	14
Q4CES0	1	1.90	1.101	10
	2	3.25	.500	4
	Total	2.29	1.139	14
Q4CES1	1	2.20	.632	10
	2	2.75	.500	4
	Total	2.36	.633	14
Q4CES2	1	2.50	.527	10
	2	2.75	.500	4
	Total	2.57	.514	14
Q4CES3	1	1.50	.707	10
	2	3.00	.816	4
	Total	1.93	.997	14
Q5CES0	1	1.80	.789	10
	2	2.25	1.258	4
	Total	1.93	.917	14
Q5CES1	1	2.20	.789	10
	2	3.00	.816	4
	Total	2.43	.852	14
Q5CES2	1	3.00	.667	10
	2	2.75	.500	4
	Total	2.93	.616	14
Q5CES3	1	2.60	.516	10
	2	3.25	.500	4
	Total	2.79	.579	14
Q6CES0	1	1.80	.632	10
	2	2.50	1.291	4
	Total	2.00	.877	14
Q6CES1	1	2.00	.816	10
	2	2.50	1.291	4
	Total	2.14	.949	14
Q6CES2	1	2.70	.823	10
	2	2.50	1.291	4
	Total	2.64	.929	14
Q6CES3	1	2.50	.527	10
	2	3.25	.500	4
	Total	2.71	.611	14
Q7CES0	1	2.00	.943	10
	2	2.75	.957	4
	Total	2.21	.975	14
Q7CES1	1	2.80	.632	10

	2	3.00	.816	4
	Total	2.86	.663	14
Q7CES2	1	3.00	.816	10
	2	2.25	.500	4
	Total	2.79	.802	14
Q7CES3	1	3.00	.667	10
	2	3.00	1.155	4
	Total	3.00	.784	14
Q8CES0	1	1.90	.738	10
	2	2.50	1.291	4
	Total	2.07	.917	14
Q8CES1	1	2.60	.843	10
	2	3.00	.816	4
	Total	2.71	.825	14
Q8CES2	1	3.40	.966	10
	2	3.25	.500	4
	Total	3.36	.842	14
Q8CES3	1	3.10	.316	10
	2	3.75	.500	4
	Total	3.29	.469	14

Multivariate Tests[a]

Effect			Value	F	Hypothesis df
Between Subjects	Intercept	Pillai's Trace	.997	212.460[b]	8.000
		Wilks' Lambda	.003	212.460[b]	8.000
		Hotelling's Trace	339.936	212.460[b]	8.000
		Roy's Largest Root	339.936	212.460[b]	8.000
	Selectors	Pillai's Trace	.837	3.218[b]	8.000
		Wilks' Lambda	.163	3.218[b]	8.000
		Hotelling's Trace	5.149	3.218[b]	8.000
		Roy's Largest Root	5.149	3.218[b]	8.000
Within Subjects	Device	Pillai's Trace	.[c]	.	.
		Wilks' Lambda	.[c]	.	.
		Hotelling's Trace	.[c]	.	.
		Roy's Largest Root	.[c]	.	.
	Device * Selectors	Pillai's Trace	.[c]	.	.
		Wilks' Lambda	.[c]	.	.
		Hotelling's Trace	.[c]	.	.
		Roy's Largest Root	.[c]	.	.

Multivariate Tests[a]

Effect			Error df	Sig.	Partial Eta Squared
Between Subjects	Intercept	Pillai's Trace	5.000	.000	.997
		Wilks' Lambda	5.000	.000	.997
		Hotelling's Trace	5.000	.000	.997
		Roy's Largest Root	5.000	.000	.997
	Selectors	Pillai's Trace	5.000	.107	.837
		Wilks' Lambda	5.000	.107	.837
		Hotelling's Trace	5.000	.107	.837
		Roy's Largest Root	5.000	.107	.837

Within Subjects	Device	Pillai's Trace	.	.	.
		Wilks' Lambda	.	.	.
		Hotelling's Trace	.	.	.
		Roy's Largest Root	.	.	.
	Device * Selectors	Pillai's Trace	.	.	.
		Wilks' Lambda	.	.	.
		Hotelling's Trace	.	.	.
		Roy's Largest Root	.	.	.

a. Design: Intercept + Selectors
Within Subjects Design: Device
b. Exact statistic
c. Cannot produce multivariate test statistics because of insufficient residual degrees of freedom.

Tests of Within-Subjects Effects

Multivariate[a,b]

Within Subjects Effect		Value	F	Hypothesis df	Error df	Sig.
Device	Pillai's Trace	.838	1.502	24.000	93.000	.087
	Wilks' Lambda	.329	1.647	24.000	84.710	.050
	Hotelling's Trace	1.561	1.799	24.000	83.000	.027
	Roy's Largest Root	1.216	4.711[c]	8.000	31.000	.001
Device * Selectors	Pillai's Trace	.734	1.255	24.000	93.000	.218
	Wilks' Lambda	.412	1.264	24.000	84.710	.215
	Hotelling's Trace	1.096	1.264	24.000	83.000	.216
	Roy's Largest Root	.685	2.655[c]	8.000	31.000	.024

Multivariate[a,b]

Within Subjects Effect		Partial Eta Squared
Device	Pillai's Trace	.279
	Wilks' Lambda	.309
	Hotelling's Trace	.342
	Roy's Largest Root	.549
Device * Selectors	Pillai's Trace	.245
	Wilks' Lambda	.256
	Hotelling's Trace	.268
	Roy's Largest Root	.407

a. Design: Intercept + Selectors
Within Subjects Design: Device
b. Tests are based on averaged variables.
c. The statistic is an upper bound on F that yields a lower bound on the significance level.

Univariate Tests

Source	Measure		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Device	Q1	Sphericity Assumed	.857	3	.286	.478	.699	.038
		Greenhouse-Geisser	.857	2.741	.313	.478	.683	.038
		Huynh-Feldt	.857	3.000	.286	.478	.699	.038
		Lower-bound	.857	1.000	.857	.478	.502	.038

	Q2	Sphericity Assumed	1.836	3	.612	.955	.425	.074
		Greenhouse-Geisser	1.836	2.436	.754	.955	.412	.074
		Huynh-Feldt	1.836	3.000	.612	.955	.425	.074
		Lower-bound	1.836	1.000	1.836	.955	.348	.074
	Q3	Sphericity Assumed	1.077	3	.359	.547	.654	.044
		Greenhouse-Geisser	1.077	2.218	.485	.547	.603	.044
		Huynh-Feldt	1.077	2.970	.363	.547	.652	.044
		Lower-bound	1.077	1.000	1.077	.547	.474	.044
	Q4	Sphericity Assumed	.948	3	.316	.521	.671	.042
		Greenhouse-Geisser	.948	2.123	.447	.521	.611	.042
		Huynh-Feldt	.948	2.807	.338	.521	.659	.042
		Lower-bound	.948	1.000	.948	.521	.484	.042
	Q5	Sphericity Assumed	5.848	3	1.949	4.237	.012	.261
		Greenhouse-Geisser	5.848	2.059	2.840	4.237	.025	.261
		Huynh-Feldt	5.848	2.699	2.167	4.237	.015	.261
		Lower-bound	5.848	1.000	5.848	4.237	.062	.261
	Q6	Sphericity Assumed	3.791	3	1.264	1.875	.151	.135
		Greenhouse-Geisser	3.791	1.979	1.916	1.875	.176	.135
		Huynh-Feldt	3.791	2.565	1.478	1.875	.161	.135
		Lower-bound	3.791	1.000	3.791	1.875	.196	.135
	Q7	Sphericity Assumed	2.729	3	.910	1.751	.174	.127
		Greenhouse-Geisser	2.729	2.688	1.015	1.751	.181	.127
		Huynh-Feldt	2.729	3.000	.910	1.751	.174	.127
		Lower-bound	2.729	1.000	2.729	1.751	.210	.127
	Q8	Sphericity Assumed	10.864	3	3.621	7.974	.000	.399
		Greenhouse-Geisser	10.864	2.350	4.624	7.974	.001	.399
		Huynh-Feldt	10.864	3.000	3.621	7.974	.000	.399
		Lower-bound	10.864	1.000	10.864	7.974	.015	.399
Device * Selectors	Q1	Sphericity Assumed	.857	3	.286	.478	.699	.038
		Greenhouse-Geisser	.857	2.741	.313	.478	.683	.038
		Huynh-Feldt	.857	3.000	.286	.478	.699	.038
		Lower-bound	.857	1.000	.857	.478	.502	.038
	Q2	Sphericity Assumed	.693	3	.231	.360	.782	.029
		Greenhouse-Geisser	.693	2.436	.284	.360	.741	.029
		Huynh-Feldt	.693	3.000	.231	.360	.782	.029

		Lower-bound	.693	1.000	.693	.360	.559	.029
	Q3	Sphericity Assumed	5.862	3	1.954	2.976	.044	.199
		Greenhouse-Geisser	5.862	2.218	2.643	2.976	.063	.199
		Huynh-Feldt	5.862	2.970	1.974	2.976	.045	.199
		Lower-bound	5.862	1.000	5.862	2.976	.110	.199
	Q4	Sphericity Assumed	3.162	3	1.054	1.738	.177	.126
		Greenhouse-Geisser	3.162	2.123	1.489	1.738	.195	.126
		Huynh-Feldt	3.162	2.807	1.127	1.738	.181	.126
		Lower-bound	3.162	1.000	3.162	1.738	.212	.126
	Q5	Sphericity Assumed	1.848	3	.616	1.339	.277	.100
		Greenhouse-Geisser	1.848	2.059	.898	1.339	.281	.100
		Huynh-Feldt	1.848	2.699	.685	1.339	.279	.100
		Lower-bound	1.848	1.000	1.848	1.339	.270	.100
	Q6	Sphericity Assumed	1.648	3	.549	.815	.494	.064
		Greenhouse-Geisser	1.648	1.979	.833	.815	.453	.064
		Huynh-Feldt	1.648	2.565	.643	.815	.479	.064
		Lower-bound	1.648	1.000	1.648	.815	.384	.064
	Q7	Sphericity Assumed	3.300	3	1.100	2.118	.115	.150
		Greenhouse-Geisser	3.300	2.688	1.228	2.118	.123	.150
		Huynh-Feldt	3.300	3.000	1.100	2.118	.115	.150
		Lower-bound	3.300	1.000	3.300	2.118	.171	.150
	Q8	Sphericity Assumed	1.150	3	.383	.844	.479	.066
		Greenhouse-Geisser	1.150	2.350	.489	.844	.457	.066
		Huynh-Feldt	1.150	3.000	.383	.844	.479	.066
		Lower-bound	1.150	1.000	1.150	.844	.376	.066
Error(Device)	Q1	Sphericity Assumed	21.500	36	.597			
		Greenhouse-Geisser	21.500	32.891	.654			
		Huynh-Feldt	21.500	36.000	.597			
		Lower-bound	21.500	12.000	1.792			
	Q2	Sphericity Assumed	23.075	36	.641			
		Greenhouse-Geisser	23.075	29.232	.789			
		Huynh-Feldt	23.075	36.000	.641			
		Lower-bound	23.075	12.000	1.923			
	Q3	Sphericity Assumed	23.638	36	.657			
		Greenhouse-Geisser	23.638	26.616	.888			

		Huynh-Feldt	23.638	35.640	.663			
		Lower-bound	23.638	12.000	1.970			
	Q4	Sphericity Assumed	21.838	36	.607			
		Greenhouse-Geisser	21.838	25.479	.857			
		Huynh-Feldt	21.838	33.685	.648			
		Lower-bound	21.838	12.000	1.820			
	Q5	Sphericity Assumed	16.563	36	.460			
		Greenhouse-Geisser	16.563	24.710	.670			
		Huynh-Feldt	16.563	32.386	.511			
		Lower-bound	16.563	12.000	1.380			
	Q6	Sphericity Assumed	24.263	36	.674			
		Greenhouse-Geisser	24.263	23.745	1.022			
		Huynh-Feldt	24.263	30.778	.788			
		Lower-bound	24.263	12.000	2.022			
	Q7	Sphericity Assumed	18.700	36	.519			
		Greenhouse-Geisser	18.700	32.257	.580			
		Huynh-Feldt	18.700	36.000	.519			
		Lower-bound	18.700	12.000	1.558			
	Q8	Sphericity Assumed	16.350	36	.454			
		Greenhouse-Geisser	16.350	28.195	.580			
		Huynh-Feldt	16.350	36.000	.454			
		Lower-bound	16.350	12.000	1.362			

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Q1	453.600	1	453.600	1395.692	.000
	Q2	355.207	1	355.207	340.318	.000
	Q3	337.902	1	337.902	2237.143	.000
	Q4	281.445	1	281.445	863.217	.000
	Q5	310.516	1	310.516	401.205	.000
	Q6	278.616	1	278.616	345.124	.000
	Q7	339.457	1	339.457	328.507	.000
	Q8	394.464	1	394.464	371.261	.000
Selectors	Q1	.457	1	.457	1.407	.259
	Q2	2.064	1	2.064	1.978	.185
	Q3	5.402	1	5.402	35.764	.000
	Q4	9.516	1	9.516	29.187	.000
	Q5	1.945	1	1.945	2.513	.139
	Q6	2.187	1	2.187	2.710	.126

	Q7	.029	1	.029	.028	.871
	Q8	1.607	1	1.607	1.513	.242
Error	Q1	3.900	12	.325		
	Q2	12.525	12	1.044		
	Q3	1.813	12	.151		
	Q4	3.913	12	.326		
	Q5	9.288	12	.774		
	Q6	9.688	12	.807		
	Q7	12.400	12	1.033		
	Q8	12.750	12	1.063		

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Measure	Partial Eta Squared
Intercept	Q1	.991
	Q2	.966
	Q3	.995
	Q4	.986
	Q5	.971
	Q6	.966
	Q7	.965
	Q8	.969
Selectors	Q1	.105
	Q2	.141
	Q3	.749
	Q4	.709
	Q5	.173
	Q6	.184
	Q7	.002
	Q8	.112
Error	Q1	
	Q2	
	Q3	
	Q4	
	Q5	
	Q6	
	Q7	
	Q8	

Appendix U: Two-factor repeated measures MANOVA: Voice activity and participations, Selectors versus Non-selectors (Objective 5B)

Between-Subjects Factors

		N
Selectors	1	12
	2	4

Descriptive Statistics

	Selectors	Mean	Std. Deviation	N
C1VAPP0	1	7.100	1.7088	12

	2	3.350	2.1205	4
	Total	6.163	2.4193	16
C1VAPP1	1	3.542	1.8966	12
	2	2.200	2.2256	4
	Total	3.206	1.9972	16
C1VAPP2	1	4.242	2.5780	12
	2	2.575	2.4446	4
	Total	3.825	2.5738	16
C1VAPP3	1	4.217	1.8800	12
	2	1.750	1.6340	4
	Total	3.600	2.0839	16
C3VAPP0	1	81.225	19.5441	12
	2	53.650	17.3700	4
	Total	74.331	22.1931	16
C3VAPP1	1	44.008	16.9880	12
	2	23.150	23.9506	4
	Total	38.794	20.3316	16
C3VAPP2	1	46.500	25.6246	12
	2	22.250	23.2718	4
	Total	40.437	26.5979	16
C3VAPP3	1	43.117	14.7623	12
	2	26.725	17.8076	4
	Total	39.019	16.6424	16
C4VAPP0	1	23.192	8.5443	12
	2	13.475	10.0390	4
	Total	20.763	9.6216	16
C4VAPP1	1	14.042	8.3210	12
	2	8.250	9.1886	4
	Total	12.594	8.6238	16
C4VAPP2	1	15.117	9.6877	12
	2	5.900	4.5424	4
	Total	12.812	9.4837	16
C4VAPP3	1	12.717	5.9740	12
	2	9.150	9.0209	4
	Total	11.825	6.7076	16
C5VAPP0	1	47.033	14.3116	12
	2	27.175	17.1023	4
	Total	42.069	16.9579	16
C5VAPP1	1	30.642	18.1305	12
	2	15.425	11.5269	4
	Total	26.838	17.7184	16
C5VAPP2	1	34.533	17.6270	12
	2	12.275	8.0342	4
	Total	28.969	18.4350	16
C5VAPP3	1	24.825	11.7411	12
	2	19.325	13.3140	4
	Total	23.450	11.9413	16

Multivariate Tests[a]

Effect			Value	F	Hypothesis df
Between Subjects	Intercept	Pillai's Trace	.922	32.718[b]	4.000

		Wilks' Lambda	.078	32.718[b]	4.000
		Hotelling's Trace	11.897	32.718[b]	4.000
		Roy's Largest Root	11.897	32.718[b]	4.000
	Selectors	Pillai's Trace	.515	2.921[b]	4.000
		Wilks' Lambda	.485	2.921[b]	4.000
		Hotelling's Trace	1.062	2.921[b]	4.000
		Roy's Largest Root	1.062	2.921[b]	4.000
Within Subjects	Device	Pillai's Trace	.894	2.103[b]	12.000
		Wilks' Lambda	.106	2.103[b]	12.000
		Hotelling's Trace	8.413	2.103[b]	12.000
		Roy's Largest Root	8.413	2.103[b]	12.000
	Device * Selectors	Pillai's Trace	.887	1.955[b]	12.000
		Wilks' Lambda	.113	1.955[b]	12.000
		Hotelling's Trace	7.821	1.955[b]	12.000
		Roy's Largest Root	7.821	1.955[b]	12.000

Multivariate Tests[a]

Effect			Error df	Sig.	Partial Eta Squared
Between Subjects	Intercept	Pillai's Trace	11.000	.000	.922
		Wilks' Lambda	11.000	.000	.922
		Hotelling's Trace	11.000	.000	.922
		Roy's Largest Root	11.000	.000	.922
	Selectors	Pillai's Trace	11.000	.072	.515
		Wilks' Lambda	11.000	.072	.515
		Hotelling's Trace	11.000	.072	.515
		Roy's Largest Root	11.000	.072	.515
Within Subjects	Device	Pillai's Trace	3.000	.295	.894
		Wilks' Lambda	3.000	.295	.894
		Hotelling's Trace	3.000	.295	.894
		Roy's Largest Root	3.000	.295	.894
	Device * Selectors	Pillai's Trace	3.000	.318	.887
		Wilks' Lambda	3.000	.318	.887
		Hotelling's Trace	3.000	.318	.887
		Roy's Largest Root	3.000	.318	.887

a. Design: Intercept + Selectors
Within Subjects Design: Device
b. Exact statistic

Tests of Within-Subjects Effects

Multivariate[a,b]

Within Subjects Effect		Value	F	Hypothesis df	Error df	Sig.
Device	Pillai's Trace	.500	2.049	12.000	123.000	.025
	Wilks' Lambda	.514	2.464	12.000	103.476	.007
	Hotelling's Trace	.917	2.879	12.000	113.000	.002
	Roy's Largest Root	.887	9.090[c]	4.000	41.000	.000
Device * Selectors	Pillai's Trace	.184	.671	12.000	123.000	.776
	Wilks' Lambda	.824	.656	12.000	103.476	.789
	Hotelling's Trace	.204	.642	12.000	113.000	.803
	Roy's Largest Root	.131	1.347[c]	4.000	41.000	.269

Multivariate[a,b]

Within Subjects Effect		Partial Eta Squared
Device	Pillai's Trace	.167
	Wilks' Lambda	.199
	Hotelling's Trace	.234
	Roy's Largest Root	.470
Device * Selectors	Pillai's Trace	.061
	Wilks' Lambda	.063
	Hotelling's Trace	.064
	Roy's Largest Root	.116

a. Design: Intercept + Selectors
Within Subjects Design: Device
b. Tests are based on averaged variables.
c. The statistic is an upper bound on F that yields a lower bound on the significance level.

Univariate Tests

Source	Measure		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Device	C1	Sphericity Assumed	43.049	3	14.350	4.251	.010	.233
		Greenhouse-Geisser	43.049	2.478	17.372	4.251	.016	.233
		Huynh-Feldt	43.049	3.000	14.350	4.251	.010	.233
		Lower-bound	43.049	1.000	43.049	4.251	.058	.233
	C3	Sphericity Assumed	9898.742	3	3299.581	12.057	.000	.463
		Greenhouse-Geisser	9898.742	2.542	3893.788	12.057	.000	.463
		Huynh-Feldt	9898.742	3.000	3299.581	12.057	.000	.463
		Lower-bound	9898.742	1.000	9898.742	12.057	.004	.463
	C4	Sphericity Assumed	504.849	3	168.283	4.400	.009	.239
		Greenhouse-Geisser	504.849	2.325	217.112	4.400	.016	.239
		Huynh-Feldt	504.849	3.000	168.283	4.400	.009	.239
		Lower-bound	504.849	1.000	504.849	4.400	.055	.239
	C5	Sphericity Assumed	1843.130	3	614.377	4.864	.005	.258
		Greenhouse-Geisser	1843.130	2.317	795.632	4.864	.011	.258
		Huynh-Feldt	1843.130	3.000	614.377	4.864	.005	.258
		Lower-bound	1843.130	1.000	1843.130	4.864	.045	.258
Device * Selectors	C1	Sphericity Assumed	10.349	3	3.450	1.022	.393	.068
		Greenhouse-Geisser	10.349	2.478	4.176	1.022	.384	.068
		Huynh-Feldt	10.349	3.000	3.450	1.022	.393	.068
		Lower-bound	10.349	1.000	10.349	1.022	.329	.068
	C3	Sphericity Assumed	205.833	3	68.611	.251	.860	.018

		Greenhouse-Geisser	205.833	2.542	80.967	.251	.829	.018
		Huynh-Feldt	205.833	3.000	68.611	.251	.860	.018
		Lower-bound	205.833	1.000	205.833	.251	.624	.018
	C4	Sphericity Assumed	76.561	3	25.520	.667	.577	.045
		Greenhouse-Geisser	76.561	2.325	32.925	.667	.542	.045
		Huynh-Feldt	76.561	3.000	25.520	.667	.577	.045
		Lower-bound	76.561	1.000	76.561	.667	.428	.045
	C5	Sphericity Assumed	493.730	3	164.577	1.303	.286	.085
		Greenhouse-Geisser	493.730	2.317	213.131	1.303	.288	.085
		Huynh-Feldt	493.730	3.000	164.577	1.303	.286	.085
		Lower-bound	493.730	1.000	493.730	1.303	.273	.085
Error(Device)	C1	Sphericity Assumed	141.776	42	3.376			
		Greenhouse-Geisser	141.776	34.694	4.087			
		Huynh-Feldt	141.776	42.000	3.376			
		Lower-bound	141.776	14.000	10.127			
	C3	Sphericity Assumed	11494.121	42	273.670			
		Greenhouse-Geisser	11494.121	35.591	322.954			
		Huynh-Feldt	11494.121	42.000	273.670			
		Lower-bound	11494.121	14.000	821.009			
	C4	Sphericity Assumed	1606.246	42	38.244			
		Greenhouse-Geisser	1606.246	32.554	49.341			
		Huynh-Feldt	1606.246	42.000	38.244			
		Lower-bound	1606.246	14.000	114.732			
	C5	Sphericity Assumed	5304.658	42	126.301			
		Greenhouse-Geisser	5304.658	32.432	163.563			
		Huynh-Feldt	5304.658	42.000	126.301			
		Lower-bound	5304.658	14.000	378.904			

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	C1	629.663	1	629.663	91.647	.000
	C3	87019.043	1	87019.043	113.812	.000
	C4	7778.794	1	7778.794	48.508	.000
	C5	33464.641	1	33464.641	62.468	.000
Selectors	C1	63.825	1	63.825	9.290	.009
	C3	5950.767	1	5950.767	7.783	.014
	C4	600.314	1	600.314	3.744	.073
	C5	2961.021	1	2961.021	5.527	.034

Error	C1	96.187	14	6.870		
	C3	10704.164	14	764.583		
	C4	2245.034	14	160.360		
	C5	7499.937	14	535.710		

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Measure	Partial Eta Squared
Intercept	C1	.867
	C3	.890
	C4	.776
	C5	.817
Selectors	C1	.399
	C3	.357
	C4	.211
	C5	.283
Error	C1	
	C3	
	C4	
	C5	

Curriculum Vitae

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Post-secondary Education and Degrees:

Western University
London, Ontario, Canada
September 2019-Present MSc

Brock University
St. Catherine's, Ontario, Canada
2016-2019 BA

Honours and Awards:

UWOSA Dependent Tuition Scholarship
Western University
2019, 2021

Deans Honour Roll
Brock University
2018, 2019

Williamson Memorial Fund Award
Brock University
2016

Brock Scholar Award
Brock University
2015, 2018

Ontario Scholar
2014

Related Work Experience

Teaching Assistant
The University of Western Ontario
2019-2021

- Introduction to Speech and Language Disorders
- SLP for Audiology
- Professional Practice Issues in SLP

Committee Services

MSc Representative
Health and Rehabilitation Sciences Graduate Student Society
The University of Western Ontario
2020-2021

Volunteer Experience

Advantage Speech Therapy Clinic
Niagara Falls, ON
2018, 2019

Lear Communication Speech Therapy Clinic
St. Catherine's, ON
2018, 2019

Presentations & Publications:

Oral Presentation – Speech and Language Sciences Seminar Series
A comparison of voice amplifiers and personal communication systems in individuals with PD: an exploration of communicative participation
Western University
October 2021

Virtual Presentation – Speech and Language Sciences Seminar Series
A comparison of voice amplifiers and personal communication systems in individuals with PD: an exploration of communicative participation
Western University
March 2021

Oral Presentation – Health and Rehabilitation Sciences Conference
A REVIEW: A comparison of voice amplifiers and personal communication systems in individuals with PD: an exploration of communicative participation
Western University
February 2021

Oral Presentation – Speech and Language Sciences Seminar Series
A comparison of voice amplifiers and personal communication systems in individuals with PD: an exploration of communicative participation
Western University
March 2020