HEARING DISABILITY AND SOCIO-EMOTIONAL ISOLATION IN AN AGING POPULATION: A REVOLUTIONARY CONCEPT ANALYSIS USING THE WORLD HEALTH ORGANIZATION'S INTERNATIONAL CLASSIFICATION OF FUNCTIONING, DISABILITY, AND HEALTH

By

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“To my husband Medhat Swelam; for all the support and love he provided me through this journey”

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LIST OF ABBREVIATIONS

ALDs	Assistive Listening Devices
AR	Audiologic Rehabilitation
HAs	Hearing Aids
HATs	Hearing Assistive Technologies
HL	Hearing Loss
ICD	International Statistical Classification of Diseases and Related Health Problems
ICF	International Classification of Functioning, Disability, and Health
ICIDH	International Classification of Impairments, Disabilities and Handicaps
WHO	World Health Organization

Abstract of Dissertation Presented to the Graduate School
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In 2010, the beta version of the International Classification of Functioning, Disability, and Health (ICF) Brief Core Set for Hearing Loss (HL) in adults was developed and recommended to be validated through audiologic rehabilitation programs (AR). The preliminary studies validated 18 of 27 categories using a clinician/researcher perspective, supported the four-factor solution provided by the ICF framework, and raised the possibility of using the ICF Brief Core Set to predict poor social interaction among elderly people with HL.

This doctoral thesis had two aims. The primary aim was to validate the ICF Brief Core Set for HL from an aging population perspective directly through the Self-Report ICF Brief Core Set Scale for HL and indirectly through the proposed model of the objective and subjective outcome measures. The secondary aim was to explore if social isolation can be predicted from the ICF Brief Core Set for HL.

One hundred and thirty one independent older adults participated in the study. All participants were either assigned to complete the objective outcome measures first and then the subjective measures or to complete the subjective outcome measures first and then the objective

measures according to their daily functioning. Both objective and subjective measures were presented in randomize order.

Twenty-two ICF Brief Core Set categories were validated from the perspective of older adults with and without HL through the Self-Reported ICF Brief Core Set Scale. Additionally, the proposed objective and subjective outcome measures validated and verified 17-20 categories and confirmed the four-factor dimensions. The overall results highlighted that life experience of older adults with hearing disability is best explained by sensor, cognitive, and psychological performances. Further, results unexpectedly highlighted the impact of dizziness in increasing listening effort and the likelihood of social isolation. Social isolation is the product of several interactions and not a certain consequence of growing older, but it is mitigated by decline in cognitive functions and health disorders. The ICF Brief Core Set Scale for HL combined with Montreal Cognitive assessment are a usefulness screening tools to be used in audiology clinical practice to predict whom at risk for social isolation and dementia.

CHAPTER 1
INTRODUCTION AND LITERATURE REVIEW

Current Disability Model

In 2001, the World Health Organization's International Classification of Functioning, Disability, and Health proposed a new model for disabilities. As opposed to the International Classification of Impairments, Disabilities, and Handicaps (ICIDH-1, 1980), the ICF is a "Biopsychosocial" model, which aims to integrate different perspectives of health into a cohesive, coherent view. The ICF was designed for optimal benefit to patients, leading to new trends in team care development and research that looked to enhance the functional capacity of the individual and to improve performance by modifying features of social environment. The ICF has been established to complement the diagnostic information provided by the International Statistical Classification of Diseases and Related Health Problems (ICD-10); however, there is a slight difference in classification procedure. The ICD-10 classifies health conditions, while the ICF classifies functioning and disability associated with health conditions.

The ICF aims to provide a unified reference framework for the description and classification of health conditions, using a standard concepts and terminology (WHO-ICF, 2001):

- Impairments: Problems in body functions and/or structures
- Activity limitations: Difficulties an individual may have in executing activities
- Participation restrictions: Problems an individual may experience in involvement in life situations.

In the context of health, Functioning represents the positive aspects of the interaction between individuals (with a health condition) and their contextual factors, which are either barriers to or facilitators of the person's functioning; while Disability represents the negative aspects. Disability is an umbrella term for impairments, and Activity limitations and Participation restrictions as shown in Figure 1-1.

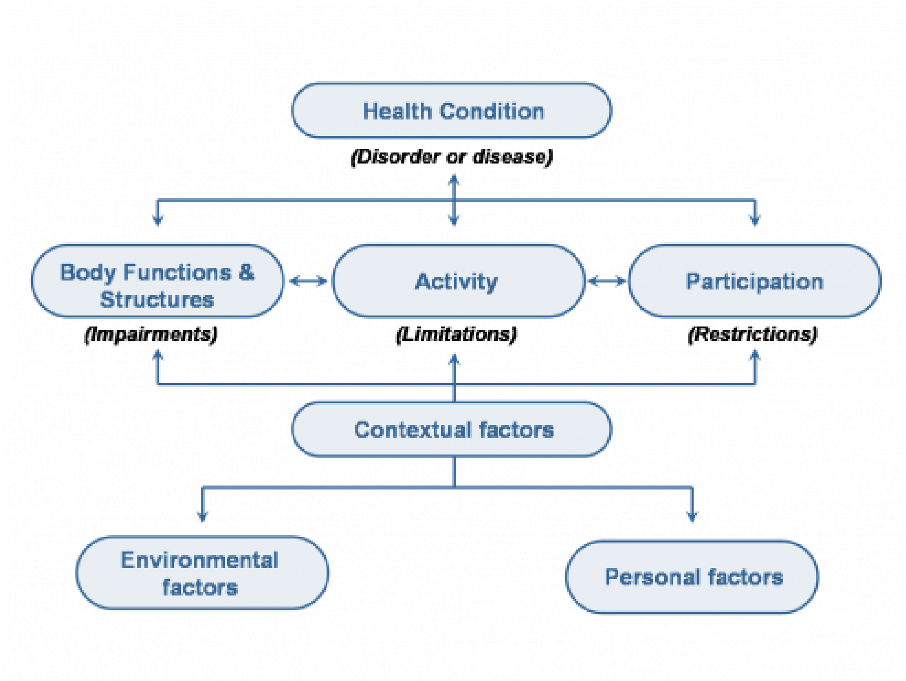

Figure 1-1: Illustration of WHO-ICF (World Health Organization, 2001) model

The ICF domains of disability have more than 1400 categories that serve as the units of the classification used to describe the individual's health. The extensive list of ICF components was the main challenge of the classification. To facilitate the use of ICF, the WHO proposed the "Core Sets Projects" that enable each clinical discipline to identify categories that are related to specific health conditions. The ICF provides textual definitions as well as inclusion and exclusion terms for each category. For example, Hearing functions (b230) defines as "Sensory functions relating to sensing the presence of sounds and discriminating the location, pitch, loudness and quality of sounds". The Inclusions are: functions of hearing, auditory discrimination, localization of sound source, lateralization of sound, speech discrimination; impairments such as deafness, hearing impairment and hearing loss. While, Exclusions are: perceptual functions (b156) and mental functions of language (b167).

The development of the ICF Core Sets recommended to be conducted in three phases: preparatory phase, an agreement by consensus phase (Phase I), and validation in clinical practice phase (Phase II) as recommend by Selb and colleagues (Selb, et al., 2014). The scheme of the three phases is illustrated in Figure 1- 2.

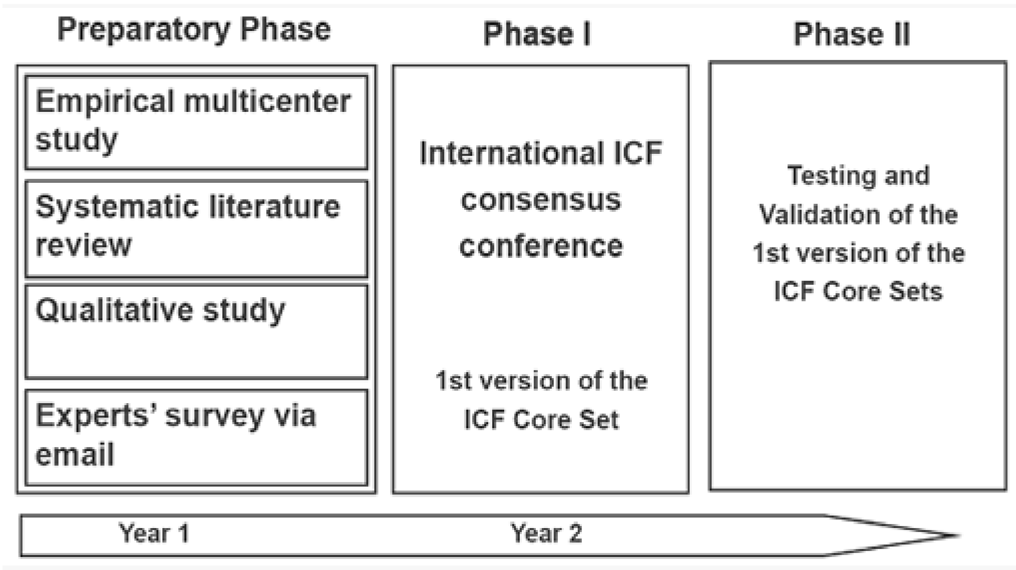

Figure 1-2. The process of developing ICF Core Sets based on Selb, et al., 2014

Emergence of the ICF Disability Model in Audiologic Rehabilitation

The ICF Core Sets for Hearing Loss (HL) development was initiated in 2010 by identifying ICF categories of particular relevance for adults with HL for use in clinical practice and research (Danermark, et al., 2005, 2010). By 2013, two beta-versions of the ICF Core Sets for HL were completed. The Comprehensive Core Set consists of 117 ICF categories and serves as a guide for multi-professional comprehensive assessment. The Brief Core Set consists of 27 categories (of the 117) and serves as a minimal standard for the assessment and reporting of functional performance and health in clinical studies (Danermark, et al., 2013). Both Core Sets were recommended to be validated through Audiologic Rehabilitation (AR) programs. Linking methodology and coding procedure is the method that was established by the WHO to validate

Core Sets Projects (Cieza, et al., 2005). Validation of the Core Sets can be carried out in different ways depending on their specific purposes (Selb et al. 2014). A Core Set can be applied as a clinical tool to support clinicians in areas such as assessment needs, measuring outcomes, and rehabilitation (Hickson & Scarinci, 2007; Timmer, et al., 2015).

Recently, three studies were conducted for validating the Core Sets for HL. The first validation study was completed through a literature review of 122 published studies by linking the Comprehensive ICF Core Set to 537 AR outcomes measures (Granberg, et al., 2014). Results highlighted two important issues. The first issue was the complexity of translating (linking) health and health related information to the ICF categories. Hence, additional rules were developed to be applied in future studies aiming to validate Core Sets in AR programs. The second issue was the lack of research focusing on communication difficulties in relation with social environmental factors (e.g. social support and/or attitudes).

The possible reasons for these findings may originate from the focus on assessing hearing performance apart from other body systems and environmental factors. Undeniably, several recommendations to modify the AR traditional test battery have been reported in the literature, yet have not been applied in AR clinical practice. For example, several studies demonstrated the value of the ICF approach over the traditional approach and suggested a significant need to use the ICF in an elderly hearing-impaired population for identifying environmental and personal factors that restrict participations (Stephens, et al., 2001; Hickson & Scarinci, 2007; Scarinci, et al., 2009) and for validating subjective outcome measures used in AR programs according to the ICF standards (Abrams & Chisolm, 2013). With the emergence of cognitive neuroscience in AR, a number of studies suggested adding global or specific cognitive screening assessments especially to the geriatric AR test battery (e.g. Kricos, 2006; Pichora-Fuller and Singh, 2006; Anderson, 2013; Anderson, et al., 2013).

In 2015, two pilot studies were conducted to explore the content validity of the ICF Brief Core Set for HL in two different clinical setting using the linking methodology (Alfakir, et al., 2015 a, b). The overall results supported Granberg and colleagues findings regarding the complexity of linking the content of the AR outcome measures to the ICF categories; and the lack of research focusing on communication difficulties in relation to social environmental factors. Further, it was aligned with a recommendation to modify the AR test battery and a need to validate subjective outcome measures used in AR programs according to the ICF standards. In the pilot studies we were able to 1) validate 18 of 27 categories, 2) identify the four-factor solutions that support the structure provided by the ICF framework, and 3) demonstrate the possibility of using the ICF Brief Core Set as a useful outcome measure to predict problems contributing to poor functional performance in elderly people with HL. In addition to the linking methodology and coding procedure, the ICF scale (qualifies) was applied to classify the severity of impairments, activity limitations, and participation restrictions. The ICF qualifiers showed to be highly reliable and remarkable to identify factors that play a role in extraordinary performance of older adults with HL. The excellent reliability of the ICF scale raised the applicability of the ICF Brief Core Set for HL to be used as an outcome measure. However, the questions were: which measures are most appropriate for addressing the ICF categories? Does ICF use represent the best clinical practice within AR programs to understand hearing disability?

Altogether, these findings raise the idea for a further validation process by using different methods rather than the linking procedure. Therefore, in the current study two different methods were proposed to validate the ICF Brief Core Set for HL, which is listed in Table 1-1. The direct method was planned to test the content validity of the ICF Brief Core Set for HL categories by developing a simple questionnaires addressing the ICF categories. The direct method was estimated from Coene (2008). The indirect method was anticipated to validate and verify the ICF categories using a proposed standardized model of outcome measurements align with the ICF Brief Core Set categories. The purpose was to develop an integrated protocol that can be used in clinical practice and future studies that helps clinicians to predict factors that contribute to hearing disability becoming a handicap or restriction.

Table 1-1. The beta-version ICF Brief Core Set

ICF Domains	
	Body Functions
b.126	Temperament & Personality function
b.140	Attention function
b.144	Memory function
b.152	Emotional function
b.210	Seeing function
b.230	Hearing function
b.240	Sensation associated with HL and vestibular function
	Body Structure
s.110	Structure of brain
s.240	Structure of external ear
s.250	Structure of middle ear
s.260	Structure of inner ear
	Activity Limitation & Participation Restriction
d.115	Listening
d.240	Handling stress and other psychological demands
d.310	Communicating with-receiving- spoken-message
d.350	Conversation
d.360	Using communication devices and techniques
d.760	Family relationship
d.820	School education
d.850	Remunerative employment
d.910	Community life
	Environmental Factors
e.125	Products & technology for communication
e.250	Sound
e.310	Support from Immediate family
e.355	Support from health professional
e.410	Individual attitudes of immediate family
e.460	Societal attitudes
e.580	Health service system & policies

Hearing Function and Hearing Disability in an Aging Population

According to the American Speech-Language-Hearing Association, hearing is defined as the process of collecting, attending to, and understanding sound from the environment (American Speech-Language-Hearing Association, 2012). There is no doubt that our hearing system is a primary window to discover the world. Throughout our lives hearing input provides us with an incredible rich and nuanced source of information. The ability to hear and listen depends on the integration of the auditory neural system from the ascending auditory pathways to the higher order functions and verse versa.

With aging, the auditory system undergoes indirect central changes as well as direct morphological and physiological changes. The indirect central changes are primarily due to peripheral lesions (degeneration of spiral ganglion), leading to a reduced input into the central auditory system. The direct changes are induced by the biological effects of aging, leading to decline in central neural auditory processing ability. These changes lead to loss of speech understanding greater than would be expected from the audiometric thresholds and a decreased ability to localize sounds and detect signals in noise. Therefore, the effect of aging on the central auditory can essentially be classified into two major types. The first is referred to as "central effect of peripheral pathology" which presents with changes in the cochlear nucleus driven by the decline of peripheral cochlear inputs that occur with age. The second is referred to as "central effects of biological aging or true aging." (Howarth & Shone, 20066). In reality, understanding the relationship between the two pathologies in the human auditory system is sophisticated and difficult to differentiate.

Three hypotheses were developed to explain age-related differences in speech recognition. First, the peripheral hypothesis suggested that poor speech recognition could be explained by aging changes in the auditory periphery (e.g. Shucknect, 1964; Humes, et al., 1996). Second, the central auditory processing hypothesis, as measured by depressed scores in speech audiometric, suggested that poor speech recognition could be explained by structural and functional changes in the auditory pathways of the brainstem and portions of auditory cortex (Humes, et al., 1992; Humes, et al., 2012). Third, the cognitive processing hypothesis, as measured by auditory cognitive tests, suggested that poor speech perception and overall communicating difficulties contributed to cognitive deficits in older adults (Jerger, et al., 1990; Jerger, et al., 1991; Humes, et al., 2007). These findings highlighted that there is no distinction between the three suggested hypotheses.

In research parallel to hearing research, neuroscientists and cognitive gerontologists proposed four hypotheses as possible explanations for the powerful inter-connection of systems between perception and cognition in aging (Lindenberger & Baltes, 1994; Baltes & Lindenberger, 1997). In brief, the common cause hypothesis suggested that declines are symptomatic of widespread neural degeneration, while the cognitive load on perception hypothesis suggested that cognitive decline results in perceptual decline. The deprivation and the information degradation hypotheses, unlike the two previous hypotheses, suggested that either perceptual decline results in permanent cognitive decline or impoverished perceptual input results in compromised cognitive performance, respectively. The information degradation hypothesis has been tested in several studies to determine the effect of changes in audition and cognition on listening performance in noisy environments and when listening becomes effortful (Pichora-Fuller, 2003). With the emergence of the deprivation and the information degradation hypotheses there was a growing interest in AR to further investigate the interacting contributions of auditory processing and cognitive processing in and its role in complex human auditory performance and behavior.

Hearing Disability

In essence, the ICF Brief Core Set for HL categories, which is listed in Table 1-1, hearing disability has two aspects:

1. Activity limitation (listening, understanding meaning of message, conversation, maintaining family relationship, and handling stress).
2. Participation restriction (employment, education, and social community life).

According to the ICF concept, these activities are highly sensitive to influence by the existence of HL and interacted with functional impairments (personality, attention, memory, emotion, hearing, vision, and other sensations associated with hearing and vestibular function), as well as environmental factors (use of assistive devices, noise, attitude, and support).

Activity Limitation

Unquestionably, HL leads to poorer perception of speech and social isolation in older adults (Pronk, et al., 2014). To compensate for the deterioration in hearing sensitivity and adjust to conversation difficulties older adults may use basic hearing aids (HAs) (Humes, 2001, 2007), specific features of hearing aids (Christensen, 2000) or assistive listening devices (ALDs) (Noe, et al., 1997; Alfakir, et al., 2015c). Byond HAs use, older adults may rely on further compensatory resources such as, cognitive working memory (Humes, 2006; Rudner, et al., 2011; Ronnberg, et al., 2013; Mishra, et al., 2014), social intelligence (Finken, 2015), and/or family/social support (Gomez & Madey, 200, Alfakir & Holmes, in progress). These findings raised three empirical questions:

First, how older adults can rely on limited social support, cognitive resources, and social intelligence if as epidemiologic studies indicate the followings:

- The prevalence of mild cognitive impairment is 42% in persons 65 years old and older, 40% to 50% of older adults report subjective memory symptoms; the prevalence of dementia is 5% in persons aged 71 to 79 years, increasing to 24% in those aged 80 to 89 years and 37% in those older than 90 years (Lin, O'Connor, et al., 2013).

- About 25% of adults aged 65 years or older have some type of mental health problem such as a mood disorder, anxiety or depression which considered a non-natural part of aging (Centers for Disease Control and Prevention, 2008).
- The prevalence of social isolation in community-dwelling older adults indicates that isolation is as high as 43% (Smith & Hirdes, 2009; Nicholson, 2009).
- About 12% of adults aged 65 or older reported that they “rarely” or “never” receive the social and emotional support they need (McGuire, et al., 2007).

Second, how older adults with HL do function if as recent longitudinal studies report the following:

- HL has increased at an average rate of 0.91 dB/year over an 11-year follow up; this rate accelerated with age, cognitive decline and hypertension (Kiely, et al., 2012).
- A systematic review study of listening comprehension across the adult lifespan found that while auditory sensitivity declined from age 20 to age 90, listening comprehension remained relatively unchanged until approximately age 65-70, with declines evident only for the oldest participants (Sommers, et al., 2011).
- Older adults with HL are at increased risk experiencing emotional distress, such as depression and social engagement restriction within three to five years later as measured (Saito, et al., 2010; Gopinath, et al., 2012).
- Dementia was evident after a six-year follow-up (Lin, et al., 2011) and personality change during a six-year follow-up (Berg & Johansson, 2014).

Third, why listening and communication difficulties and social isolation are still the most common complaints among older listeners in both treated and untreated HL (Humes, et al., 2006; Mick, et al., 2014; Dawes, et al., 2015).

Indeed, all of these factors may contribute to limiting activities, increasing the listening effort, and restricting participation in social interactions and/or increasing the likelihood of social isolation. In other words, all these factors may contribute to turning disability into a handicap or restriction. Obviously, being able to answer those questions requires an innovative concept analysis and integrative understanding of the comprehensive profile of an individual instead of focusing only on the auditory system. This doctoral study proposes that the use of the ICF Brief Core Set for HL helps in:

- Investigating the complex relationship between hearing disability and social isolation in the aging population.
- Identifying factors that may be responsible in turning hearing disability into handicap or restriction.

Participation Restriction

In psychology, social intelligence is the ability to build personal connections with others, deal with conflict, and be part of a positive social network. This indicates that social intelligence requires high cognitive and executive abilities to perform day-to-day activities such as listening , handling breakdowns in communication and information processing, maintaining relationships with family and friends including an adequate network of people and strong social ties, and regulating negative societal attitudes (Hess & Blanchard-Fields, 1999).

Three major psychological theories have been proposed to explain how people develop in old age, the disengagement, activity, and continuity theories. The disengagement theory states that “normal aging is an inevitable mutual withdrawal or disengagement by the aging individual and society to which he or she belongs” (Cumming & Henry, 1961). However, this theory raised several controversial issues in the field of aging, because it ignores the impact of low social support on aging life experiences with disabilities. In 1963, the activity theory rose in opposing response to the disengagement theory. The activity theory proposes that “successful aging occurs when older adults stay active and maintain social interactions” (Havighurst, 1963). This theory emphasizes two important issues. The first issue is the importance of maintaining an active lifestyle. The second issue is the role of social structure including relationships with family and friends that help older people to stay active and continue to maintain their own integrity. With the emergence of behavior observational studies in a large proportion of older adults with changing physical, mental, and social status the continuity theory was originated in 1989. The continuity theory proposes that “older adults will usually maintain the same activities, behaviors, relationships as they did in their earlier years of life” (Atchley, 1989). This theory highlighted two fundamental structures of continuity that help people maintain their social interaction situations, the internal and external structures. Personality, ideas, and beliefs of an individual are some examples of the internal structure, while relationships and social roles are some examples of the external structure that support elderlies for maintaining their lifestyle, regardless of their health problems. These theories highlighted multifaceted factors of social isolation.

In 2003, the WHO revealed that “social isolation is associated with increased rates of premature death, lower general well-being, more depression, and a higher level of disability from chronic diseases” (WHO, 2003). Social isolation refers to the objective physical separation from other people, such as living alone or having a small social network and/or inadequate social support (Foundation of AARP, 2012). Emotional isolation or loneliness refers more to the subjective feeling of being alone, separated, or apart from others (Biordi & Nicholson, 2009). Social isolation in effect, not only disrupts an individual’s ability to self-regulate social environment (e.g. noise, lack of social support…etc.), but also increased attention deficit as measured by a cognitive test called dichotic listening (Cacioppo, et al., 2000, 2014). Hence, with health problems associated with HL in older adults, the probability of social isolation or poor social interaction, when auditory comprehension was limited, is very high (Mick, et al., 2014).

The in-depth analysis of the qualitative data, which was extracted from the two pilot studies, using the framework of functional assessment of behavior approach, found that older people strive to continue participating, completely or partially, in social events regardless of the HL and perceived handicap. However, this ability improves in the presence of positive support and attitude, while restriction in term of feeling loneliness and social isolation seems to increase with maladaptive coping strategies, inability to handle stress, and/or lack of social support (Alfakir & Holmes, in progress). This altogether raises the interest in applying the ICF Brief Core Set for HL as a holistic approach to explore the factors behind this behavior.

Research Aims

Primary Aim: The primary aim is to validate the ICF Brief Core Set for HL from the aging population perspective in two ways: directly through the self-reported ICF Brief Core Set Scale for HL and indirectly through the proposed model of standardized objective and subjective outcome measures. Validation will be achieved by:

1. Testing the correlation between the responses to the self-reported ICF Brief Core Set Scale for HL and the proposed model of outcome measures to support validity of ICF items. These include:

- Body functions domain: 1) personality, 2) emotion, 3) attention, 4) memory, 5) vision 6) hearing, 7) sensation related hearing (tinnitus), and 8) sensation related vestibular (dizziness).

- Activities and participation: 1) listening, conversation, communication, and using communication techniques will be combined as communication difficulties, 2) family relationships, and 3) community life.

- Environmental factors: 1) products and technology 2) sound, and 4) support from family.

2. Evaluating the content validity, factor structure, and reliability of the self-reported ICF Brief Core Set Scale for HL.

3. Evaluating the adequacy of the proposed model of the objective and subjective outcome measures as a supplemental procedure to validate the ICF Brief Core Set for HL.

Secondary Aim: The secondary aim is to explore if social isolation can be predicted from the proposed model of the objective and subjective outcome measure aligned with the ICF Brief Core Set for HL. Figure 1-3 illustrated the hypothesized model used to predict social isolation. The hypothesized model was derived from the literature review, ICF framework, and the pilot studies to reflect the complex interactions of environmental factors, functional performance, and activities limitation on social isolation.

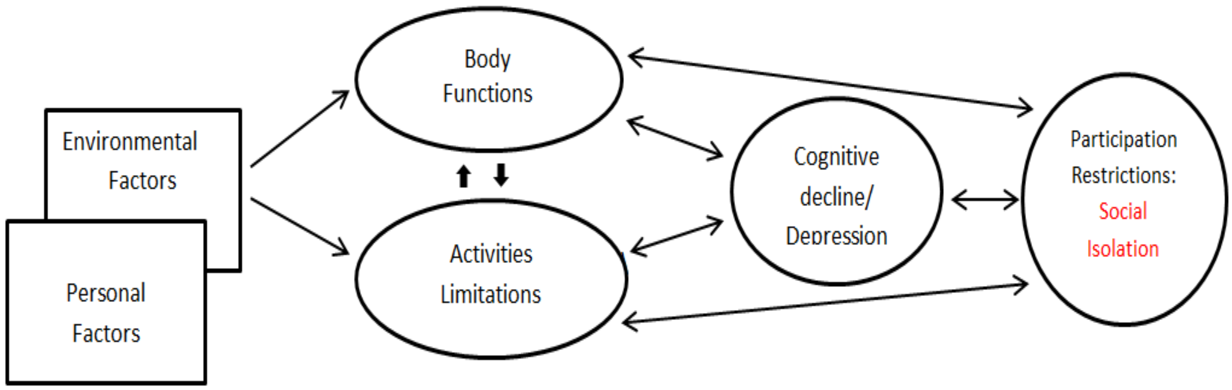

Figure 1-3. The hypothesized (*A Priori*) model predicting social isolation in older adults

CHAPTER 2
METHODS

Setting

This study was completed at the University of Florida. Testing took place in the Audiologic Rehabilitation Laboratory in Dauer Hall. For participants, one visit was required to complete the study lasting for 3 hours including the break.

Demographics

Participants were 131 independent older adults whom ages between 60 and 89 year (mean [*M*] = 72.32, standard deviation [SD] = 6.83). Fifty five of the 131 participants (58%) were male. Fifty four of 131 participants (40.5%) had completed 14 to 16 years of education were the rest more or less educated. The majority of the participants were retired (71.8%), living with a spouse (65.6%), had multiple health conditions (76.3%), such as high blood pressure, diabetes, or arthritis, had non-hearing assistive devices technology (68.7%), and a corrective seeing function (e.g. eye glasses or surgery) (76%). Eighty five of 131 participants had HL above 25dB (85%). Seventy seven had a normal cognitive function (MoCA >26), forty eight had a mild cognitive decline (MCI) (MoCA $\leq$ 26), and seven had a severe cognitive decline (MoCA $\leq$ 21). Detailed participant characteristics are provided in (Table 2-1).

Table 2-1. Participants Characteristics (N =131)

Characteristics	Number = 131	Mean(SD)	Range
Age		72.32 (6.83)	60-89
60-69	52		
70-79	55		
80-89	24		
Gender			
Male	55		
Female	76		
Education Levels			
12 years	26		
14 - 16 years	53		
>16 years	52		
Work status			
Retired	94		
Employed	28		
Volunteers	9		
Living arrangements			
Live with spouse	86		
Live with other relatives	13		
Live alone	32		
Health conditions			
No medical disorders	31		
Chronic medical disorders	100		
Use of HATs			
None	90		
HAs only	29		
HAs + ALDs	9		
ALDs only	3		
Have corrected vision			
Yes (distance)	100		
Yes (close)	115		
Intellectual function (MoCA)			
Normal cognition > 26	77		
MCI $\leq$ 26	48		
Severe cognitive Decline $\leq$ 21	6		

Objective Outcome Measures

Pure Tone Audiometry Test (PTA)

Only air conduction testing was completed in both ears. The Hughson Westlake technique was used to evaluate thresholds for the 250, 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz frequencies. The calculation of the average thresholds for each ear was based on the 500, 1000, 2000, and 4000Hz frequencies.

Acceptable Noise Level (ANL)

The ANL is a test developed by Nabelek and colleagues to determine an individual's willingness to accept noise when listening to speech (Nabelek, et al., 1991). The ANL requires listeners to report the most comfortable listening level (MCL) for ongoing speech (Arizona Travelogue) in an adaptive procedure. Then they continue listening to the speech at their MCL while background noise is introduced and again in an adaptive procedure the listener's most comfortable level for the background noise while still listening to the speech is determined (BNL). The ANL calculation can then be made by subtracting the BNL from the MCL (ANL=MCL-BCL). A lower score means a greater tolerance of background noise.

Bamford-Kowal-Bench Speech in Noise Test (BKB-SIN)

The BKB-SIN consists of 18 equivalent sentence pairs, each list containing 8-10 sentences presented in increasing levels of background noise or changing in Signal-to-Noise Ratio (SNR) (Bench, et al., 1979). All sentences are produced by one talker and the background noise by four talker babble. The SNRs range from +21 to -6 in each list. The BKB-SIN is scored in a dB SNR breakdown with lower scores indicating better speech understanding in noise. In this study only a two-list pair (No. 3 and 4) was used for all participants. The SNR loss scores for the four lists were averaged to create a combined SNR loss score. The scores of 3-7 indicates a mild SNR loss and scores of 7-15 indicates moderate SNR loss, while scores > 15 dB indicates severe SNR loss.

Brief Test of Attention (BTA)

The BTA is an auditory perception task that measures divided attention in the verbal-linguistic system developed by (Schretlen, 1996). It provides a rapid, bedside assessment of attention impairment among non-aphasic hearing adults, including those with visual and motor impairments that preclude tests which require visual scanning or manual dexterity. It is standardized for use with adults' ages 17-89 years who can distinguish between spoken numbers and spoken letters of the alphabet. The BTA consists of two parallel forms presented via audio CD. On Form N (Numbers), a voice reads ten lists of letters and numbers that increase in length from 4-18 elements. The respondent's task is to disregard the letters presented and cognitively count how many numbers were read aloud. Form L (Letters) consists of the same ten lists, but the respondent must disregard the numbers and cognitively count how many letters were read aloud. The number of correctly monitored lists is summed across both forms, with raw scores ranging from 0-20. Test materials include the Professional Manual, the Stimulus Audio CD, and the Scoring Form. It takes 10-15 minutes to administer.

Digit Span Test-Backward (DSB)

The DSB was initially designed to measure working attention and memory (Wechsler, 1997). DSB is used to measure working memory's number storage capacity. Participants repeated digit strings of increasing length in reverse order.

A list of random numbers was presented once by visual-only (DSB-V) modality via a computer screen at the rate of one digit per second and once by listening-only (DSB-L) modality via a voice recording by a native English speaker at a rate of one digit per second. The list consisted of 8 sets or 16 trials. The score was the total number of correct trials prior to failing two consecutive trials at any one span size (Gregoire & Van der Linden, 1997). Higher scores indicated better performance.

Montréal Cognitive Assessment (MoCA)

MoCA (version 7.1) is a cognitive screening tool designed to assist health professionals in detection of mild cognitive impairment (MCI). It assesses different cognitive domains: visuo-constructional skills/executive functions, attention and concentration, memory, language, abstract, and orientation. The total possible score is 30 points; the suggested cutoff score for normal cognitive function was > 26 (29.6 – 25.2), < 26 (25.2 – 19.0) for MCI and any score range from (21.0 – 11.4) considered as a risk for Alzheimer's disorder (Nasreddine, et al., 2005).

Visual Acuity Test

Visual acuity was assessed with standard optometric procedures for both close and distance vision. An Ultimate Eye Snellen chart was presented at about 14 inches (close visual acuity) from the participants' eyes and at about 6 feet from eyes (distance visual acuity). Both tests were performed according to daily functioning.

Subjective Outcome Measures

Demographics information sheet

This sheet includes the general information about their age, gender, education, occupation, marital, medical history status, and HAs use.

Self-Report ICF brief core set scale for HL

This is a self-reported questionnaire developed by the researcher. The theme of the questionnaire was based on another doctoral thesis aimed to at validating the ICF Core Set for Arthritis (Coene, 2008). The questionnaire was designed based on the description of the ICF Brief Core Set for HL categories (ICF manual, 2001 or online ICF browser). Also, the rating scale was designed based on the ICF qualifiers related to each domain (ICF manual, 2001). The ICF Brief Core Set Scale for HL can be seen in the Appendices.

Big Five Personality Inventory 44-item (BFPI)

BFPI is an inventory that measures an individual on the Big Five Factors (dimensions) of personality (Goldberg, 1993). Each of the factors is then further divided into personality facets:

- Extraversion (8 items)
- Agreeableness (9items)
- Conscientiousness (9 items)
- Neuroticism (8 items)
- Openness (10 items)

Each questionnaire item probed respondents for a rating on a scale of 1 =disagree strongly, 2= disagree a little, 3=neither agree nor disagree, 4= agree a little, 5=agrees strongly.

Tinnitus functional index (TFI)

TFI is one of the most systematically validated methods of assessing a patient's reaction to their tinnitus (Meikle, et al., 2011). TFI is a self-reported outcome designed to assess the multiple domains of tinnitus severity. Each domain had at least three or four items. Each questionnaire item asked respondents for a rating on a scale of 0 to 10, based on how they experienced their tinnitus "over the past week". For example, a typical question read, "Over the past week, how easy was it for you to cope with your tinnitus?" with potential responses from 0 being "very easy to cope" to 10 being "impossible to cope." Higher scores indicate a more severe handicap.

Dizziness Handicap Inventory (DHI)

The DHI has been developed by Jacobson and Newman (1990). The DHI consists of 25 questions grouped into three dimensions: functional, emotional, and physical aspects of dizziness and unsteadiness. The scores ranged from 0-100 points. There were nine questions within each of the functional and emotional dimensions; with a maximum score of 4 for each item. Within the physical dimension there were seven questions with a maximum score of 4 for each. Higher scores indicate a more severe handicap.

Speech, Spatial and Quality of Hearing (SSQ)

SSQ is a self-report test of auditory disability developed by Gatehouse and Noble in 2004. The SSQ includes 49 items that ask how well a listener would do in many complex listening situations illustrative of real life that covers: 1) hearing speech in a variety of competing contexts; 2) the directional, distance and movement components of spatial hearing; 3) segregation of sounds and attending to simultaneous speech streams; 4) ease of listening; 5) the naturalness, clarity and identifiability of different speakers, different musical pieces and instruments, and different everyday sounds. Each item describes a unique listening situation, and the patient answers on a scale of 0-10 to indicate how much difficulty individuals would have. Higher scores indicate more effortful listening.

The Geriatric Depression Scale (GDS)

GDS is a 30-item self-report assessment used to identify depression in the elderly. The GDS questions are answered "yes" or "no", instead of a five-category response set. This simplicity enables the scale to be used with ill or moderately cognitively impaired individuals. The scale is commonly used as a routine part of a comprehensive geriatric assessment. One point is assigned to each answer and the cumulative score is rated on a scoring grid. The grid sets a range of 0-9 as "normal", 10-19 as "mildly depressed" and 20-30 as "severely depressed" (Yesavage, et al., 1982).

Loneliness and Social Isolation Scale of De Jong Gierveld (LSIS-DJG)

LSIS-DJG is an 11 item scale. Each item represents a statement with a three-point response scale (no, more or less, yes). It includes the objective measure (social isolation) that relates to deficits in social integration and embeddedness and the subjective (emotional loneliness) that relates to the absence of an intimate attachment figure such as a partner or best friends (De Jong Gierveld & Kamphuis, 1985). The loneliness subscale consisted of 6 items, while the social isolation subscale involved 5 items. Higher scores indicate severe social isolation.

Lubben Social Network Scale-Revised (LSNS-R)

LSNS-R consists of an equally weighted sum of 6, 12, or 18 items designed to gauge social isolation in older adults by measuring perceived social support received from family (6 items), friends (6 items) , and neighborhood (6 items) (Lubben & Gironda, 2004). The items measure size, closeness, and frequency of contacts of a respondent's social network. It was originally developed in 1988 and was revised in 2002 (LSNS-R) along with an abbreviated version (LSNS-6) and an expanded version (LSNS-18). Higher scores indicate high level of social support.

Relationship Assessment Scale (RAS)

RAS is a short version 7-item scale designed to measure general relationship satisfaction. Respondents answer each item using a 5-point scale ranging from 1 (low satisfaction) to 5 (high satisfaction) (Hendrick, 1988). Higher scores indicate high level of family relationship satisfaction.

Equipment

Otoscopy was completed at the beginning of the session using a Welch Allyn otoscopy. All objective testing was completed in a walled sound treated booth. The baseline audiometric testing was performed using a GSI 650 audiometer and ER-2 insert phones calibrated prior to beginning the study. Additionally each test was calibrated prior to beginning the study. All objective tastings were presented in a sound field. The BKB-SIN, ANL, and the BTA were routed through the diagnostic audiometer to a wall mounted speaker in the sound field. These testing were conducted with sound presentations from a speaker at 0 degree azimuth and the participant sitting one meter from the speaker. The DSB measure was presented via a Dell computer. For the listening tasks the computer was attached to an external computer speaker and the participant sitting half meter from the external speaker. The loudness level for the BKB-SIN, BTA, and listening DSB outcome were obtained at approximately 65-70 dB SPL.

Procedures

All participants were recruited from the community through flyers and post-cards sent to the University of Florida Audiology clinics, the University Of Florida Institute Of Aging, the University of Florida Health Street, and local senior citizen centers, local audiology clinics and senior living housing developments. First, all participants consented to be part of the study, which was approved by the UF Institutional Review Board on the use of human subjects and which conforms to the Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects. Next, if the participants were a HAs users, the function of the HAs were checked either by Real Ear Measurement or a listening check. Third, participants were either assigned to complete the objective outcome measures first and then the subjective or to complete the subjective outcome measures first and then the objective measures. Both objective and subjective measures were randomized in order. All participants were asked to complete both outcomes measures according to their daily functioning. For example, if participants were HAs users, the BKB-SIN was completed while the participants used the HAs.

CHAPTER 3
RESULTS

Data Analysis

All statistics were completed using the IBM SPSS VERSION 21 and AMOS VERSION 22. The statistical analysis used in this study includes: descriptive statistics, bivariate correlation coefficient, factors analysis, and structure equation modeling.

Descriptive Statistics

Descriptive Statistics for the Self-Reported ICF Brief Core Set Scale for HL

Results showed that 100% of the ICF categories were reported by the 131 participants in response to the Self-Reported ICF Brief Core Set Scale for HL in Table 3-1, 3-2, and 3-3.

For Body Functions Domain

The health problems that were most reported to mildly limit (1=mild) and completely restrict participation (4= complete) in social interaction were 81% for memory loss and 75.6% for hearing dysfunction. While 48% reported limitations and restrictions due to temperament and personality functions, 45% due to attention deficits, 42% due to mental illness, and 40% due to sensation of tinnitus. Whereas the health problems that were least reported to limit and restrict participation in social interaction were 28% for distance acuity vision and 20% for sensation of dizziness or fear of falling. The frequency distribution for each item per scale (0=no impairment, 1=mild, 2=moderate, 3=severe, and 4=complete) is presented in Table 3-1.

For Activity Limitation and Participation Restriction

The activities that were most reported to mildly limit to completely restrict social interaction were 65% due to handling stress and other psychological demands, 60% due to using communication techniques (communication repair strategies), 52% due to listening and communication with-receiving-spoken messages, 46% due to conversation. While the activities that were least reported to limit and restrict social interaction were 28% due to family relationship and 26% for involvement in community life. The frequency distribution for each item per scale (0=no difficulty, 1=mild, 2 =moderate, 3=severe, and 4=complete) is presented in Table 3-2.

For Environmental Factors

Among the HAs users, 28 out of 38 reported that in using HAs or HATs, clarity of sound, and the soundness level was a facilitator. Among all participants, 110 out of 131 reported that background noise was a barrier ranging from the mild to substantial to complete, 62 out of 131 reported that loud sound was a barrier, 14 out of 131 reported that family support was a barrier, 19 out of 131 reported that family attitude was a barrier, and only 9 out of 131 reported that social attitude was a barrier. The frequency distribution for items of environmental domain per scale (-1=mild barrier, -2= moderate barrier, -3=severe barrier, - 4=complete barrier, 0=no barrier neither facilitator, +1=mild facilitator, +2= moderate facilitator, +3= Substantial facilitator, +4= complete facilitator) is presented in Table 3-3.

Table 3-1. The frequency distribution for items of body function domain per scale (0=no impairment, 1=mild, 2=moderate, 3=severe, and 4=complete) from the 131 participants

Body Functions	Frequency distribution and percentage				
	0	1	2	3	4
Temperament & Personality function	67 (51.1%)	47 (35.9%)	11 (8.4%)	5 (3.8%)	1 (.8%)
Attention function	71 (54.2%)	48 (36.6%)	6 (4.6%)	5 (3.8%)	1 (.8%)
Memory function	25 (19.1%)	76 (58%)	22 (16.8%)	7 (5.3%)	1 (.8%)
Emotional function	73 (55.7%)	40 (30.5%)	9 (6.9%)	6 (4.6%)	3 2.3%)
Seeing function (Far distance)	94 (71.8%)	27 (20.6%)	6 (4.6%)	3 (2.3%)	1 (.8%)
Hearing function	32 (24.4%)	49 (37.4%)	32 (24.4%)	14 (10.7%)	4 (3.1%)
Sensation associated with HL (Tinnitus)	78 (59.5%)	22 (16.8%)	14 (10.7%)	7 (5.3%)	10 (7.6%)
Sensation associated with HL (Vestibular)	107 (80.2%)	17 (13%)	5 (3.8%)	3 (2.3%)	1 (.8%)

Table 3-2. The frequency distribution for items of disability domain per scale (activity limitation and participation restrictions) per scale (0=no difficulty, 1=mild, 2=moderate, 3=severe, and 4=complete) from the 131 participants

Activity Limitations and participation restriction	Frequency distribution and percentage				
	0	1	2	3	4
Listening	56 (42.7%)	46 (35.1%)	17 (13%)	8 (6.1%)	4 (3.1%)
Handling stress and other psychological demands	50 (35.2%)	64 (48.9%)	9 (6.9%)	7 (5.3%)	1 (.8%)
Communicating with-receiving-spoken-message	62 (47.3%)	52 (39.7%)	12 (9.2%)	4 (3.1%)	1 (.8%)
Conversation	71 (54.2%)	42 (32.1%)	8 (6.1%)	8 (6.1%)	2 (1.5%)
Using communication techniques	52 (39.7%)	39 (29.8%)	15 (11.5%)	18 (13.7%)	7 (5.3%)
Family relationship	94 (71.8%)	31 (23.7%)	5 (3.8%)	1 (.8%)	0
Remunerative employment	125 (95.4%)	5 (3.8%)	1 (.8%)	0	0
Community life	97 (74%)	25 (19.1%)	4 (3.1%)	5 (3.8%)	0

Table 3-3**.** The frequency distribution for items of environmental domain per scale (-1=mild barrier, -2= moderate barrier, -3=severe barrier, - 4=complete barrier, 0=no barrier neither facilitator, +1=mild facilitator, +2= moderate facilitator, +3= Substantial facilitator, +4= complete facilitator) from the 131 participants

Environmental Factors	Barrier					Facilitator			
	-4	-3	-2	-1	0	+1	+2	+3	+4
Among 38 HAs users:									
Technology for communication									
✓ Use of HAs	0	2	1	4	3	3	10	10	5
✓ Clarity of sound	0	2	6	3	0	6	11	9	2
✓ Loudness of sound	0	4	2	2	3	5	9	10	3
Among 131 participants									
Sound									
✓ Noise background	4	18	46	42	21	0	0	0	0
✓ Loud sound of speech	1	32	20	9	24	26	10	8	1
Support from Immediate family	1	0	1	12	49	19	15	16	18
Support from health professional	0	0	0	4	72	16	7	16	16
Family attitudes	1	0	5	13	66	10	8	13	15
Societal attitudes	0	0	2	8	70	17	12	14	8
Health service system & policies	0	0	1	8	74	13	8	14	13

Descriptive Statistics for the Proposed Objective and Subjective Outcome Measures

Descriptive statistics with directionality of the scores for objective and subjective outcome measures among the 131 participants and the 85 participants with HL above 25 dB (the HL group) can be seen in table 3-4, 3-5, 3-6, and 3-7.

Objectives Outcome Measures

For the hearing sensitivity as measured by PTA

The mean hearing threshold for average HL in both ears among the 131 participants was 33 dB HL, (*SD*=16.3). The mean hearing threshold for average HL in both ears among the HL group was 41.5 dB HL (*SD*=14). Forty asymmetric audiograms were identified across the entire sample size.

For visual acuity as measured by Snellen chart

The mean score for the distance visual acuity for the 131 was 0.84 *(SD=0.2).* The mean score for the close visual acuity for the 131 was 0.85 *(SD=0.16).* The mean for both tests among the HL group were almost identical.

For hearing function as measured by the BKB-SIN

The mean score for the BKB-SIN or the Signal-to-Noise-Ratio loss among the 131 participants was 0.42 dB *(SD=3.4).* The mean hearing threshold BKB-SIN among the HL group was 1.3 dB *(SD=4.3).*

For attention function as measured by BTA

The mean score for the BTA among the 131 participants was *15.2 (SD=4.4).* The mean score among the HL group was *14.3(SD=5).*

For memory function as measured by DSB via listening-only and visual-only modalities

The mean score for the DSB via listening-only modality among the 131 participants was *7.5 (SD=2).* The mean score for the DSB via visual-only modality among the 131 participants was *7(SD=2).* The mean for both tests among the HL group were almost identical.

For the global cognitive function as measured by MoCA

The mean score for the MoCA among the 131 participants was *26.5(SD=3).* The mean score for the MoCA among the HL group was *26 (SD=3).*

For the noise background as measured by ANL

The mean score for the ANL among the 131 participants was *3.5(SD=4).* The mean score for the ANL among the HL group was *3.4(SD=4).*

Subjective outcome measures

For the sensation of tinnitus as measured by TFI

The mean score for the TFI among the 131 participants was *7.3 (SD=13.4).* The mean score for the TFI among the HL group was *10 (SD=15.4).*

For sensation of dizziness as measured by DHI

The mean score for the DHI among the 131 participants was *8.0 (SD=12).* The mean score for the DHI among the HL group was *9.3(SD=13.3).*

For the effortful listening construct as measured by SSQ

The mean score for the SSQ among the 131 participants was *7.4 (SD=1.6).* The mean score for the SSQ among the HL group was *7 (SD=1.6).*

For the depression function as measured by GDS

The mean score for the GDS among the 131 participants was *5.2 (SD=5.3).* The mean score for the GDS among the HL group was *5.5 (SD=5.3).*

For personality and temperament function as measured by BFPI

Among the 131 participants the mean score for the Extroversion personality type was *3.3 (SD=0.8),* Agreeableness *4.0 (SD=0.5),* Conscientiousness *4.0 (SD=0.6),* Neuroticism *2.4 (SD=0.8, and openness 3.7(SD=0.6).* The mean for the BFPI among the HL group were almost identical.

For family support as measured by LSNS-R

The mean score for the LSNS-12 among the 131 participants was *37.34 (SD=9).* The mean for the LSNS-12 among the HL group were almost identical.

For the family relationship as measured by RAS

The mean score for the RAS among the 131 participants was *31 (SD=5).* The mean for the LSNS-12 among the HL group were almost identical.

For the social isolation as measured by LSIS-DJG

The mean score for the LSIS-DJG among the 131 participants was *3.3 (SD=2.7).* The mean for the LSIS-DJG among the HL group were almost identical.

Table 3-4. Descriptive statistics of the objective and subjective outcome measures for the 131 participants

Objective outcome measures				
Scale	Mean	SD	Min	Max
PTA of Right Ear (average of 500, 1, 2, & 4KHz)	32.98	18.17	7.50	120.0
PTA of Left Ear (average of 500, 1, 2, & 4KHz)	32.68	16.56	5.00	88.75
PTA of Both ears (average of 500, 1, 2, & 4KHz)	32.98	16.28	8.75	100.0
BKB-SIN Test (lower score better)	0.42	3.67	-3.0	23.50
Visual Acuity (distance) (Higher score better)	0.84	0.19	0.40	1.00
Visual Acuity (close) (Higher score better)	0.85	0.16	0.40	1.00
BTA (Higher score better)	15.16	4.39	2.00	20.00
DSB-L (Higher score better)	7.50	2.03	4.00	14.00
DSB-V (Higher score better)	6.92	2.06	3.00	13.00
MoCA (Higher score better)	26.46	2.62	18.00	30.00
ANL (lower score better)	3.46	4.06	-2.00	12.00

Table 3-5. Descriptive statistics of the objective and subjective outcome measures for the 131 participants

Subjective outcome measures				
Scale	Mean	SD	Min	Max
TFI (lower score better)	7.31	13.40	0.00	58.8
DHI (lower score better)	7.82	11.77	0.00	62.0
SSQ (Higher score better)	7.37	1.62	1.14	9.77
GDS (lower score better)	5.18	5.35	0.00	27.0
BFPI				
✓ Extraversion	3.31	0.85	1.38	5.00
✓ Agreeableness	4.06	0.55	2.00	5.00
✓ Conscientiousness	3.93	0.61	2.40	5.11
✓ Neuroticism	2.43	0.87	1.00	5.38
✓ Openness	3.76	0.67	2.00	5.00
LSNS-R (Higher score better)				
✓ LSNS-R-6	19.47	4.83	6.00	29.0
✓ LSNS-R-12	37.34	8.83	9.00	56.0
✓ LSNS-R-18	47.43	12.75	10.0	80.0
RAS (Higher score better)	30.91	4.83	17.0	35.0
LSIS-DJG-Total (lower score better)	3.27	2.77	0.00	11.0
✓ Loneliness sub scale	1.48	1.68	0.00	6.00
✓ Social isolation sub scale	1.81	1.68	0.00	5.00

Table 3-6. Descriptive statistics of the objective and subjective outcome measures for the 85 participants with HL above 25dB (the HL group)

Objective outcome measures				
Scale	Mean	SD	Min	Max
PTA of Right Ear (average of 500, 1, 2, & 4KHz)	41.80	16.49	17.5	120.0
PTA of Left Ear (average of 500, 1, 2, & 4KHz)	40.47	14.97	10.0	88.75
PTA of Both ears (average of 500, 1, 2, & 4KHz)	41.47	13.92	26.0	100.0
BKB-SIN Test (lower score better)	1.28	4.28	-3.00	23.5
Visual Acuity (distance) (Higher score better)	0.83	0.20	0.40	1.00
Visual Acuity (close) (Higher score better)	0.84	0.17	0.40	1.00
BTA (Higher score better)	14.28	4.75	2.00	20.0
DSB-L (Higher score better)	7.51	1.95	4.00	12.0
DSB-V (Higher score better)	6.86	2.20	3.00	13.0
MoCA (Higher score better)	26.31	2.78	18.0	30.0
ANL (lower score better)	3.89	4.08	-2.00	12.0

Table 3-7. Descriptive statistics of the objective and subjective outcome measures for the 85 participants with HL above 25dB (the HL group)

Subjective outcome measures				
Scale	Mean	SD	Min	Max
TFI (lower score better)	9.81	15.44	0.00	58.8
DHI (lower score better)	9.32	13.26	0.00	62.0
SSQ (Higher score better)	6.91	1.65	1.14	9.61
GDS (lower score better)	5.53	5.36	0.00	27.0
BFPI				
✓ Extraversion	3.27	0.84	1.50	5.00
✓ Agreeableness	4.04	0.53	2.00	5.00
✓ Conscientiousness	3.91	0.63	2.40	5.11
✓ Neuroticism	2.42	0.90	1.00	5.38
✓ Openness	3.79	0.68	2.00	4.80
LSNS-R (Higher score better)				
✓ LSNS-R-6	19.36	5.04	6.0	28.0
✓ LSNS-R-12	37.33	8.78	9.0	56.0
✓ LSNS-R-18	47.93	12.39	10.0	80.0
RAS (Higher score better)	30.84	4.50	17.0	35.0
LSIS-DJG-Total (lower score better)	3.41	2.64	0.0	11.0
✓ Loneliness sub scale	1.61	1.69	0.0	6.0
✓ Social isolation sub scale	1.80	1.63	0.0	5.0

Correlation Coefficient between Proposed Objective and Subjective Outcome Measures and Aligned Categories of Self-Reported ICF Brief Core Set Scale for HL

The results of a bivariate correlation coefficient analysis of the objective and subjective outcome measures for the131 participants are shown in the following Tables: 3-6a and 3-6b.

1. There was a significant correlation between the individuals responses to the BFPI outcome and the effect of four types of temperament and personality function from the Self-Reported ICF Brief Core Set scale for HL: *Extroversion ($r = -.17, p=.044$), Agreeableness ($r = -.30, p=.001$), Conscientiousness($r = -.23, p=.007$), and Neuroticism ($r = .32, p < 0.001$);* while there is a non-significant correlation with *Openness ($r = -.03; p=.73$).*
2. There was a significant correlation between the individual's responses to the BTA outcome and the attention function from the Self-Reported ICF Brief Core Set scale for HL *($r = -0.30, p = 0.001$).*
3. There was a significant correlation between the individuals responses to the listening and visual working memory outcome and the memory function from Self-Reported ICF Brief Core Set scale for HL *[(r (DSB-L) = - 0.27, $p = 0.002$; r (DSB-V) = - .24, $P = .004$]*.
4. There was a significant correlation between the individuals responses to the GDS outcome and the emotion function from the Self-Reported ICF Brief Core Set scale for HL *($r = 0.50, p < 0.001$).*
5. There was a significant correlation between the individuals responses to the BKB-SIN outcome and the hearing function from the Self-Reported ICF Brief Core Set scale for HL *($r = .57, p < 0.001$).*
6. There was a significant correlation between the individuals responses to the Snellen chart outcome (distance) and the seeing function from the Self-Reported ICF Brief Core Set scale for HL *($r = - 0.36, p < 0.001$).*

7. There was a significant correlation between the individuals responses to the TFI and the tinnitus sensation from the Self-Reported ICF Brief Core Set scale for HL *($r = .80$, $p < 0.001$).*

8. There was a significant correlation between the individuals responses to the DHI and the vestibular function from the Self-Reported ICF Brief Core Set scale for HL *($r = - 0.50$, $p < 0.001$).*

9. There was a significant correlation between individuals responses to the SSQ and the listening, communication with verbal spoken message, conversation, and using communication techniques from the Self-Reported ICF Brief Core Set scale for HL *[r (listening) = - 0.62, p < 0.001; r (communication with verbal spoken message) = -.65, p < 0.001; r (conversation) = -.6, p < 0.001; r (using communication techniques) = -.50, p < 0.001]*. Also, there is a significant correlation with handling stress *($r = -.41$; $p < 0.001$).*

10. There was a significant correlation between the individuals responses to the RAS and the family relationships (activities and participation domain) from the Self-Reported ICF Brief Core Set scale for HL *($r = - 0.17$, $p = 0.042$; $r = .18$, $p = .032$).*

11. There was a significant correlation between the individuals responses to the LSIS-DJG and the community life (activities and participation domain) from the Self-Reported ICF Brief Core Set scale for HL *($r = - 0.32$, $p < 0.001$).*

12. There was a significant correlation between the individuals responses to the ANL (environment factors) and the sound from the Self-Reported ICF Brief Core Set scale for HL *($r = - 0.26$, $p = 0.002$).*

13. There was a significant correlation between the individuals responses to the LSNS-12 and the family support (environment factors) from the Self-Reported ICF Brief Core Set scale for HL *($r = 0.20$, $p = 0.020$).*

Further bivariate correlation coefficient analysis completed for the 85 participant with HL > 25dB showed very slight differences as shown in Tables 3-8 and 3-9.

Table 3-8. Correlation coefficient between ICF items and objective outcome measures for the 131 participants versus the 85 participant who have HL > 25dB

		Objective Outcome measure		
ICF Items	Domain	Outcome measure	R (n=131)	R(n=85)
Hearing Function	Body Function	BKB-SIN	0.57***	0.57***
Seeing Function	Body Function	Snellen chart (distance)	-0.36***	-0.45***
Attention function	Body Function	BTA	-0.30**	-0.30**
Memory function	Body Function	DSB-L (Tasks)	-0.23**	-0.27**
		DSB-V (Tasks)	-0.21**	-0.24**
		DSB-L (Cap)	-0.27**	-0.31**
		DSB-V (Cap)	-0.24**	-0.30**
Sound	Environmental	ANL	-0.26**	-0.38***

****** P <0.001, ** P <0.01, * P < 0.05*

Table 3-9. Correlation coefficient between ICF items and subjective outcome measures for the 131 participants versus the 85 participant who have HL > 25dB

Subjective Outcome measure				
ICF Items	Domain	Outcome measure	R(n=131)	R(n=85)
Temperament & Personality function	Body Function	BFPI		
		✓ *Extroversion*	-0.17*	-0.16
		✓ Agreeableness	-0.30**	-0.21*
		✓ Conscientiousness	-0.23**	-0.22*
		✓ Neuroticism	0.32**	0.27*
		✓ Openness	-0.03	-0.01
Emotional function	Body Function	GDS	0.50***	0.47***
		LSIS-DJG (Emotional)	0.44***	0.45***
Structure of Ear	Body Structure	PTA	0.64***	0.76***
Sensation of Tinnitus	Body Function	TFI	0.83***	0.84***
Sensation of Dizziness	Body Function	DHI	0.50***	0.54***
Listening,	Activity and Participation	SSQ	-0.62***	-0.57***
Communicating,			-0.65***	-0.62***
Conversation,			-0.63***	-0.61***
Using communication technique			-0.50***	-0.45***
Handling stress			-0.41***	-0.41***
Family relationship	Activity and Participation	RAS	-0.17*	-0.23**
Community life	Activity and Participation	LSIS-DJG (Total scale)	0.32***	0.35***
		LSIS-DJG (Social)	0.26**	0.23**
Support from family	Environmental	LSNS-12	0.20**	0.21*
Product &Technology	Environmental	HA & ALDS usage	0.35***	0.27**

***** *P <0.001, ** P <0.01, * P < 0.05***

Factor Analysis and Structure Equation Modeling

Exploratory Factor Analysis (EFA) for the Self-Reported ICF Brief Core Set Scale for HL

The EFA was conducted to determine the relationships between the ICF items and to support the four dimensions of the ICF structures using the participant's responses to the ICF brief core set scale for HL in this sample. A *maximum-likelihood* with orthogonal oblique rotations (promax) methods for Likert/ordinal data (ICF qualifiers) was applied to the 22 items for the study sample of 131 participants. The Kaiser-Meyer-Olkin (KMO) measure verified the sampling adequacy for the analysis, KMO = .88. An initial analysis was run to obtain eigenvalue for each factor in the date. Bartlett's test (Approx. Chi-square [(X^2 (231) =1556.44, P < 0.001), indicated that the relation between items were sufficiently large for the analysis. The Goodness-of-fit Tests (GOF) indicated a good fit (X^2 (149) = 169.995, P =.115). Four factors over Kaiser's criterion of 1 suggested by scree plot, and in combination, explained 55.3 % of the variance. These were:

- F1. Non Auditory Functions and Participation
- F2. Environmental Resources
- F3. Auditory Functions and Limitation
- F4. Family Relationship (Third Party Disability)

The rotated structure showed that Factor 1 and 3 were highly correlated (r = 0.65), Factor 2 and 3 were fairly correlated (r = 0.2), while Factor 4 was shown to be independent. The loadings of items on factors, communalities, percent of variance per factor after rotation, and correlation matrix are presented in Table 3-10.

The internal consistency, Cronbach's alpha coefficient for the Self-Report ICF Brief Core Set for HL including items from the body functions and activities and participation scales was .89, while Cronbach's alpha coefficient for the 26 items including the environmental items was .83.

Table 3-10. Pattern (unique contribution of a variable to a factor), structure (where shared variance not ignored), communalities (loadings of items on factors) (h2), and percent of variance using the maximum likelihood method

ICF model with the 22 items									
	Rotated pattern matrix				Rotated structure matrix				
Items	F1	F2	F3	F4	F1	F2	F3	F4	h^2
Hearing function	-.16	-.00	.97	.15	.50	.17	.88	.25	.82
Seeing function (Far)	.52	.05	.20	-.20	.60	.11	.48	-.05	.40
Tinnitus	-.10	.02	.45	-.01	.20	.08	.39	.02	.16
Vestibular/balance function	-.51	.07	.16	-.30	.57	-.02	.45	-.18	.41
Temperament and personality	.77	-.00	-.20	.16	.68	.04	.35	.25	.51
Attention function	.70	.00	-.04	.31	.70	.08	.44	.40	.60
Memory function	.43	.12	.22	.20	.60	.22	.54	.30	.50
Emotional function	-.70	-.01	-.04	.03	.67	.04	.41	.12	.50
Listening	.01	-.10	.82	.02	.54	.05	.81	.11	.70
Communication	.10	-.07	.77	-.07.	.60	.06	.82	.02	.70
Conversation	.30	.03	.53	.16	.64	.16	.73	.30	.61
Communication techniques	-.04	.08	.76	-.24	.42	.19	.72	-.15	.60
Handling stress	.70	-.06	.01	.11	.70	.01	.45	.20	.50
Family relationship	.40	-.08	.07	.50	.46	.00	.35	.54	.45
Community life	.72	-.00	-.07	-.08	.66	.04	.40	.00	.44
HA-Use	-.01	.54	.06	.02	.00	.54	.10	.06	.30
Background noise	-.01	-.08	-.60	-.14	-.43	-.20	-.64	-.22	.44
Family support	-.02	.82	-.06	-.08	-.00	.80	.05	-.02	.65
Family attitude	.05	.81	.00	-.22	.09	.80	.20	-.14	.70
Social attitude	.01	.80	.10	-.06	.22	.82	.31	.03	.71
Health support	-.03	-.88	-.06	.21	.03	.90	.10	.28	.84
Health services	-.02	-.83	-.02	.02	.04	.83	.12	.10	.70
Total Variance explained = 55.3 %									
Percent of variance	28.5.0%	17.4%	6.4%	3.0%					
Correlations Matrix					1.00	0.08	0.65	0.13	
					0.08	1.00	0.20	0.09	
					0.65	0.20	1.00	0.11	
					0.13	0.09	0.11	1.00	
Kaiser-Meyer-Olkin of sampling adequacy = .88, P < 0.01									

F1. Non Auditory Functions and Participation
F2. Environmental Resources
F3. Auditory Functions and Limitation
F4. Family Relationship (Third Party Disability)

Confirmatory Factor Analysis (CFA) for the Self-Reported ICF Brief Core Set Scale for HL

In this analysis the CFA using the *IBM SPSS AMOS* was applied to evaluate the adequacy of the Self-Reported ICF Brief Core Set Scale for HL. The Goodness-Of-Fit (GOF) indices which were selected to test the CFA model that best represents the present dataset were: Chi-Square, Root-Mean-Squared Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Tucker Lewis Index (TLI). A GOF has:

- A probability level greater than 0.05 when chi-square is close to zero.
- RMSEA, which is related to residual in the model, value 0.06 or less.
- CFI and TLI values of 0.90 or greater.

The CFA using the *Maximum likelihood estimates method* was performed. The CFA confirmed the four-factor solution across the 131 participants. The GOF statistics of the CFA model indicated a marginal support [X^2 (204) = 316.493, P < 0.10; TLI = .911; CFI = .921; RMSEA = .065, Pclose =0.043]. However, Bollen-Stine bootstrap was done to test the null hypothesis that the model is correct. Bollen-Stine bootstrap supported the fit of the model (P = 0.208). All the 22 ICF items were significantly related to the proposed latent variable.

Using the modification indices, the GOF indices were improved by determining the correlation between (Vestibular (e1) and seeing functions (e8)). The GOF become [X^2 (203) = 298.098, P = 0.000; TLI = .923; CFI = .933; RMSEA = .060, Pclose =0.132]. Bollen-Stine bootstrap supported the fit of the model (P = 0.291). Further, the CFA model was tested by the *Generalized Least Square method*. The GOF statistics of the CFA model significantly support the model fit [X^2 *(203)* = 219.009, P = 0.210; TLI = .829; CFI = .851; RMSEA = .025, Pclose = 0.976].

The Model, which is presented in Figure 3-1, illustrates the results of Maximum likelihood estimates method. Additional details about the standardized and unstandardized regression weight, standard error, covariance, and correlation estimates for the CFA Model are presented in Table 3-11.

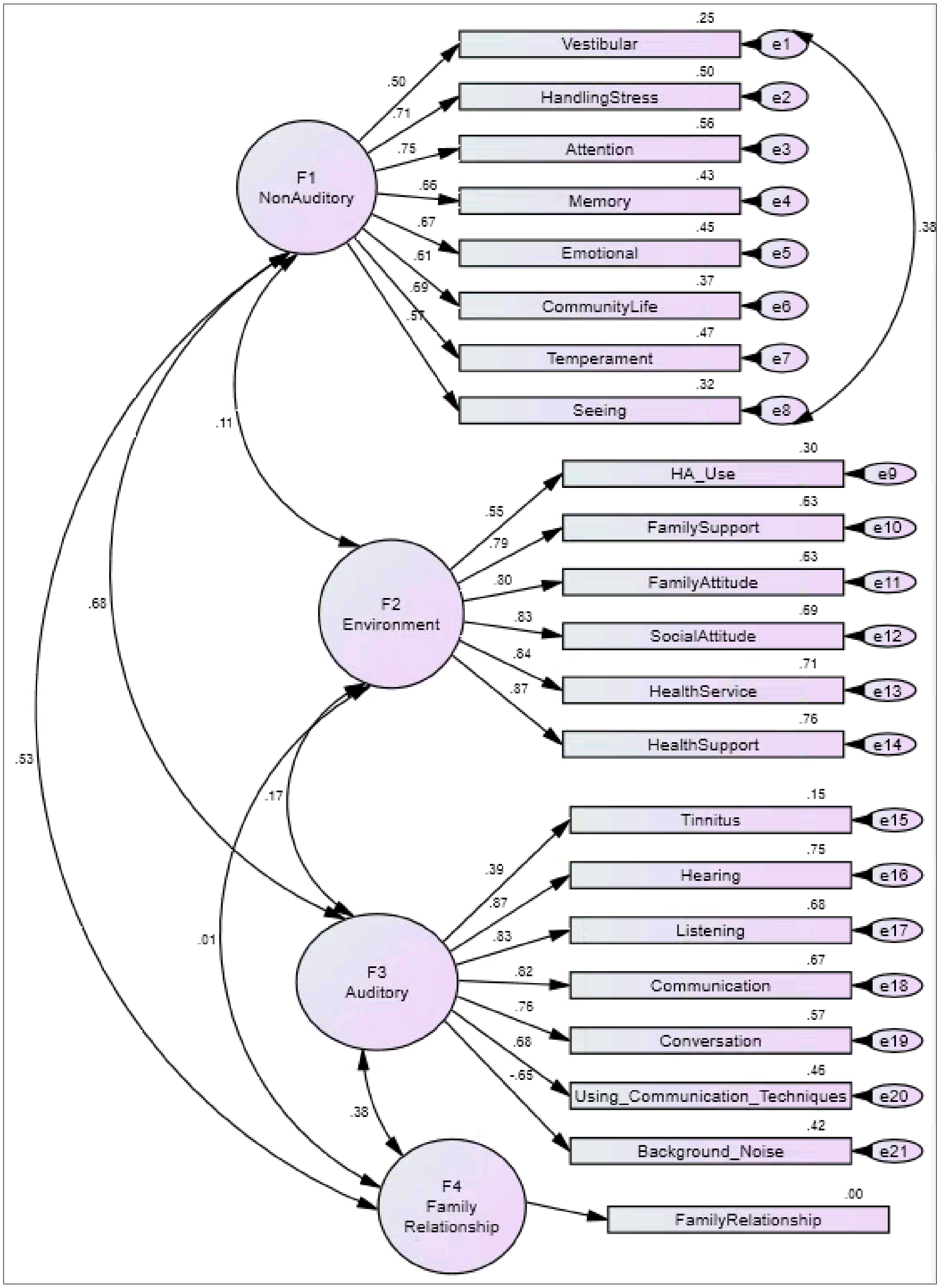

Figure 3-1. The CFA model of the Self-Reported ICF Brief Core Set Scale for HL; Circles represent latent variables, Rectangles represent measured variables, Represent the error/ uniquenesses, Arrows represents variance from observed to latent variables, Correlation arrows represent correlation between factors or between error/uniquenesses, and decimal numbers represent correlation estimate.

Table 3-11. The standardized and unstandardized regression weight, standard error, covariance, and correlation estimates for the CFA Model

Regression Weights Estimates					
Outcome measures (Indicators)		B	ß	SE	P Value
Vestibular	<---F1_NonAuditory	1.000	.500	.315	P < .001
Handling Stress	<---F1_NonAuditory	1.650	.709	.315	P < .001
Attention	<---F1_NonAuditory	1.685	.750	.287	P < .001
Memory	<---F1_NonAuditory	1.454	.658	.348	P < .001
Emotional	<---F1_NonAuditory	1.788	.674	.251	P < .001
Community Life	<---F1_NonAuditory	1.221	.607	.317	P < .001
Temperament	<---F1_NonAuditory	1.607	.686	.199	P < .001
Seeing	<---F1_NonAuditory	1.177	.565		
HA_Use	<---F2_Environment	1.000	.551	.300	P < .001
Family Support	<---F2_Environment	1.906	.793	.301	P < .001
Family Attitude	<---F2_Environment	1.925	.795	.252	P < .001
Social Attitude	<---F2_Environment	1.653	.829	.273	P < .001
Health Service	<---F2_Environment	1.802	.841	.281	P < .001
Health Support	<---F2_Environment	1.892	.870		
Tinnitus	<--- F3_Auditory	1.000	.389	.415	P < .001
Hearing	<--- F3_Auditory	1.860	.869	.395	P < .001
Listening	<--- F3_Auditory	1.747	.827	.311	P < .001
Communication	<--- F3_Auditory	1.368	.820	.337	P < .001
Conversation	<--- F3_Auditory	1.454	.755	.410	P < .001
Using_Communication_Techniques	<--- F3_Auditory	1.712	.680	.326	P < .001
Background_ Noise	<--- F3_Auditory	-1.346	-.650		P < .001

Exploratory Factor Analysis (EFA) for the Standardized Outcome Measures

A *Maximum-Likelihood* with orthogonal oblique rotations (Promax) methods for the standardized outcome measures was applied to the 22 items for the study sample of 131 participants. The EFA model reveled on six factors over Kaiser's criterion of 1 and in combination, explained 54.3 % of the variance. However, the scree plot suggested the four factors as can be seen in Figure 3-2.

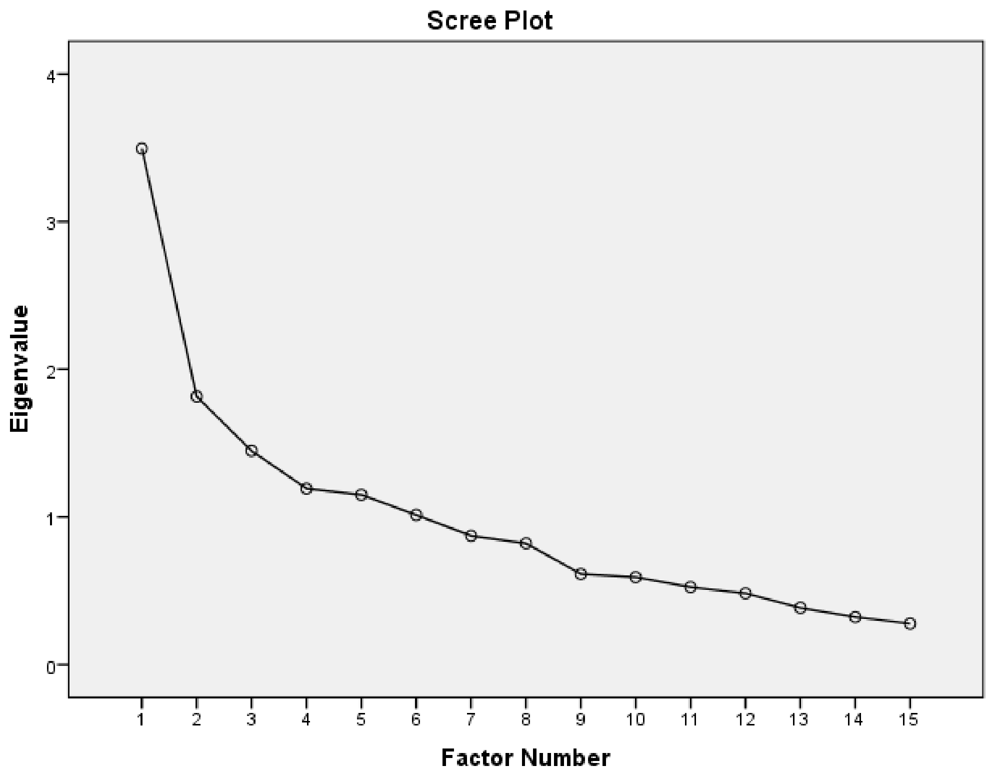

Figure 3-2. The scree plot supported the 4-factor solutions for the standardized outcome measures.

The EFA was completed with the four-factor solution. The Kaiser-Meyer-Olkin (KMO) measure verified the sampling adequacy for the analysis, KMO = .70. An initial analysis was run to obtain eigenvalue for each factor in the date. Bartlett's test (Approx. Chi-square [($\chi 2$ (105) =440.832, $P < 0.01$), indicated that the relation between items were sufficiently large for the analysis. The Goodness-of-fit Tests (GOF) indicated a good fit ($X^2(51) = 50.738$; $P < 0.01$). The four factor solution explained 40.8 % of the variance. These Factors named as:

- F1. Non-Sensory Functions
- F2. Sensory Functions and Limitation
- F3. Psychosocial and Restriction.
- F4. Family Relationship (Third Party Disability)

The rotated structure showed that Factor 1, 3, and 4 were highly correlated (r = 0.43, r = - 0.43) respectively, Factor 2 and 3 were fairly correlated (r = - 0.26). Further details of the loadings of items on factors, communalities, percent of variance per factor after rotation, and correlation matrix are presented in Table 3-12.

Table 3-12. Pattern (unique contribution of a variable to a factor), structure (where shared variance not ignored), communalities (loadings of items on factors) (h2), and percent of variance using the maximum likelihood method

ICF model with the 15 outcome measures									
	Rotated pattern matrix				Rotated structure matrix				
Items	F1	F2	F3	F4	F1	F2	F3	F4	h^2
Memory (DSB-L)	.081	.76	.03	.04	-.07	.75	-.14	.14	.57
Memory (DSB-V)	.044	.84	-.02	-.00	-.12	.83	-.21	.14	.69
Global Cognitive (MoCA)	-.12	.43	-.10	.09	-.30	.50	-.30	.26	.30
Hearing Function (BKB-SIN)	.51	.07	.02	-.32	.65	-.10	.40	-.55	.52
Tinnitus (TFI)	.31	.04	.05	.08	.30	-.02	.15	-.06	.09
Vestibular (DHI)	.45	.05	.14	.14	.45	-.04	.30	-.09	.23
Depression (GDS)	.26	-.02	.47	.12	.42	-.17	.55	-.16	.35
Attention (BTA)	.02	.05	-.04	.97	-.44	.26	-.40	.99	.99
SSQ	-.94	.10	.11	-.05	-.88	.24	-.30	.33	.80
Social Isolation (LSIS-DJG)	-.07	.03	.92	.01	.32	-.20	.88	-.30	.78
Family Relationship (RAS)	-.08	.05	-.30	-.30	-.09	.08	-.21	-.13	.10
Family Support (LSNS-12)	.06	.03	-.53	.11	-.21	.18	-.54	.30	.30
HAs Use	.41	.07	-.07	-.22	.46	-.02	.16	-.36	.25
Background noise (ANL)	.22	.02	-.03	-.01	.20	-.01	.05	-.08	.04
Vision (Distance)	.02	.10	.043	.12	-.05	.11	-.03	.15	.03
Total Variance explained = 40.8 %									
Percent of variance	23.3%	12.10%	9.6%	7.9%					
Correlations Matrix					1.00	-0.20	0.43	-0.43	
					-0.20	1.00	-0.26	0.20	
					0.43	-0.26	1.00	-0.35	
					-0.43	0.20	-0.35	1.00	
Kaiser-Meyer-Olkin of sampling adequacy = .70, P < 0.01									

F1. Sensory Functions and Limitation
F2. Non-Sensory Functions
F3. Psychosocial and Restriction
F4. Family Relationship (Third Party Disability)

Confirmatory Factor Analysis for the Standardized Outcome Measures

In this analysis the CFA using the *IBM SPSS AMOS* was applied to evaluate the adequacy of the proposed model of the objective and subjective outcome measures as a supplemental procedure to validate the ICF Brief Core Set for HL.

The CFA for the four-factor solution was examined using the *SPSS* to obtain a rough estimate of the factor structure of the outcome measures. The outcome measures included in each factor were:

- **Factor 1:** DSB-V, DSB-L, and MoCA. This factor named as: Non-Sensory Functions.
- **Factor 2:** Visual acuity (distance), BBK-SIN, TFI, DHI, SSQ, ANL, BTA, and HATs use. This factor named as Sensory Functions and Limitation.
- **Factor 3:** LSNS-12, LSIS-DJG, GDS. This factor named as Psychosocial and Restriction.
- **Factor 4:** RAS. This factor named as Family Relationships (Third -Party Disability).

The CFA using the *IBM SPSS AMOS* and the *Maximum likelihood estimates method* was performed. The CFA confirmed the four-factor solution across the 131 participants. The GOF statistics of the CFA model indicated a marginal support [X^2 (85) = 120.775, P = 0.007; TLI = .88; CFI = .90; RMSEA = .057, Pclose =0.300; AIC = 208.133; BIC = 314.515]. However, Bollen-Stine bootstrap was done to test the null hypothesis that the model is correct. Bollen-Stine bootstrap supported the fit of the model (P = 0.054). The removal of the visual acuity test had not support the model fit. The normality assumption of the univariate distributions showed a reasonable range of skewness and kurtosis and an acceptable joint multivariate value (1.41; c.r. 0.360). All the outcome measures were significantly related to the proposed latent variable except for the distance visual acuity test.

To improve model, the modification indices were used. Two high correlations of error terms were identified within Factor 2 (DHI, SSQ, and ANL) and between Factor 2 and 3 (DHI and LSID-DJG). By correlating the error term between the DHI, SSQ, and ANL outcome measures, within Factor 2, the model was significantly improved. The GOF statistics for the improved model was [X^2 (83) = 103.207, P = .066; TLI = .93; CFI = .94; RMSEA = .043, Pclose = 0.644]. This Model is presented in Figure 3-3. Additional details about the standardized and unstandardized regression weight, standard error, covariance, and correlation estimates for the CFA Model are presented in Table 3-13.

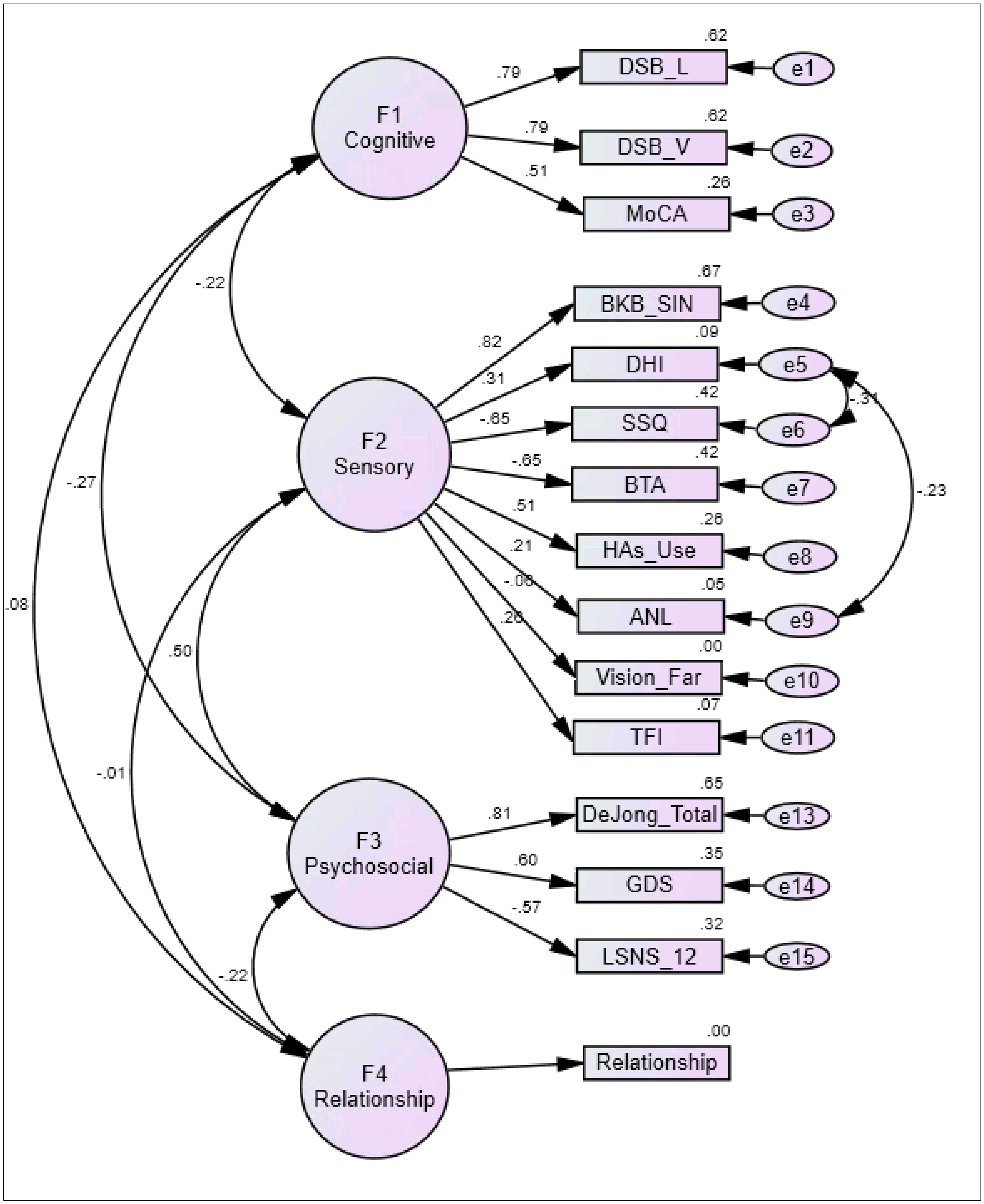

Figure 3-3. The CFA model of outcome measures representing the 4-factors solution. Circles represent latent variables, Rectangles represent measured variables, Represent the error/ uniquenesses, Arrows represents variance from observed to latent variables, Correlation arrows represent correlation between factors or between error/uniquenesses, and decimal numbers represent correlation estimate

Table 3-13. The standardized and unstandardized regression weight, standard error, covariance, and correlation estimates for the CFA Model

Regression Weights Estimates						
Outcome measures (Indicators)			B	ß	SE	P Value
DHI	<---	F2_Sensory	.325	.308	.105	P =.002
SSQ	<---	F2_Sensory	-1.304	-.648	.200	P < .001
BTA	<---	F2_Sensory	-.770	-.650	.117	P < .001
DeJong Total	<---	F3_Psychosocial	1.000	.806		
GDS	<---	F3_Psychosocial	.253	.596	.050	P =.001
LSNS_12	<---	F3_Psychosocial	-2.243	-.567	.434	P =.001
DSB_L	<---	F1_Cognitive	1.000	.788		
DSB_V	<---	F1_Cognitive	1.014	.788	.167	
BKB_SIN	<---	F2_Sensory	1.000	.818		
HAs Use	<---	F2_Sensory	.286	.507	.057	P < .001
MoCA	<---	F1_Cognitive	.837	.512	.168	P =.008
ANL	<---	F2_Sensory	1.076	.214	.489	P =.027
TFI	<---	F2_Sensory	.267	.263	.100	P < .001
Vision Far	<---	F2_Sensory	-.013	-.056	.024	P =.571

F1. Non-Sensory Functions or Cognitive Functions
F2. Sensory Functions and Limitation
F3. Psychosocial and Restriction
F4. Family Relationship (Third-Party Disability)

Structure Equation Modeling (SEM) for the Self-Reported ICF Brief Core Set Scale for HL

A SEM with *Maximum Likelihood* method was applied to evaluate if social isolation can be predicted from the Self-Reported ICF Brief Core Set Scale for HL according to the *a priori* model, which was presented in Figure 1-3. The model includes 18 ICF items:

- *Body Functions:* Temperament, Attention, Memory, Seeing, Hearing, Vestibular, and Tinnitus.
- *Activity Limitations:* Listening, Communication, Conversation, Using communication techniques, handling stress, Family relationship, and Community life.
- *Moderator/Mediation:* Emotion Function
- *Environmental Factors:* HAs Use, Background Noise, and Family Support
- *Social Isolation:* two subscales of LSIS-DJG

The GOF statistics were (X^2 (161) = 347.130, P = 0.000; TLI = .78; CFI = .81; RMSEA=0.091, Pclose = 0.000). To improve the model:

- Temperament was excluded from the model.
- Correlations between covariates were added.

The modification improves the model. The GOF statistics (X^2 (140) = 208.493, P = 0.000; TLI = .90; CFI = .92; RMSEA=0.061, Pclose = 0.143). However, Bollen-Stine bootstrap was done to test the null hypothesis that the model is correct. Bollen-Stine bootstrap supported the fit of the model (P = 0.203). The GOF statistics using the *Generalized Least Square* (X^2 (140) = 134.494, P < 0.01; TLI = 1.12; CFI = 1.00; RMSEA=0.000, Pclose = 0.995). The SEM model with listing of standardized coefficient (ß) is presented in Figure 3-4.

Direct Effect

- Background noise item associated with a significant negative effect on body functions (ß = - .70, P < 0.001) and a positive effect on activity limitations (ß = .18, P = 0.033).

- Body Functions associated with a significant positive effect on activity limitations (ß = 1.1, P < 0.001) and with negative effect on social isolation (ß = -.45, P = 0.001).

- Emotion function item associated with a significant positive effect on social isolation (ß = .49, P < 0.001). Further details are presented in Table 3-14.

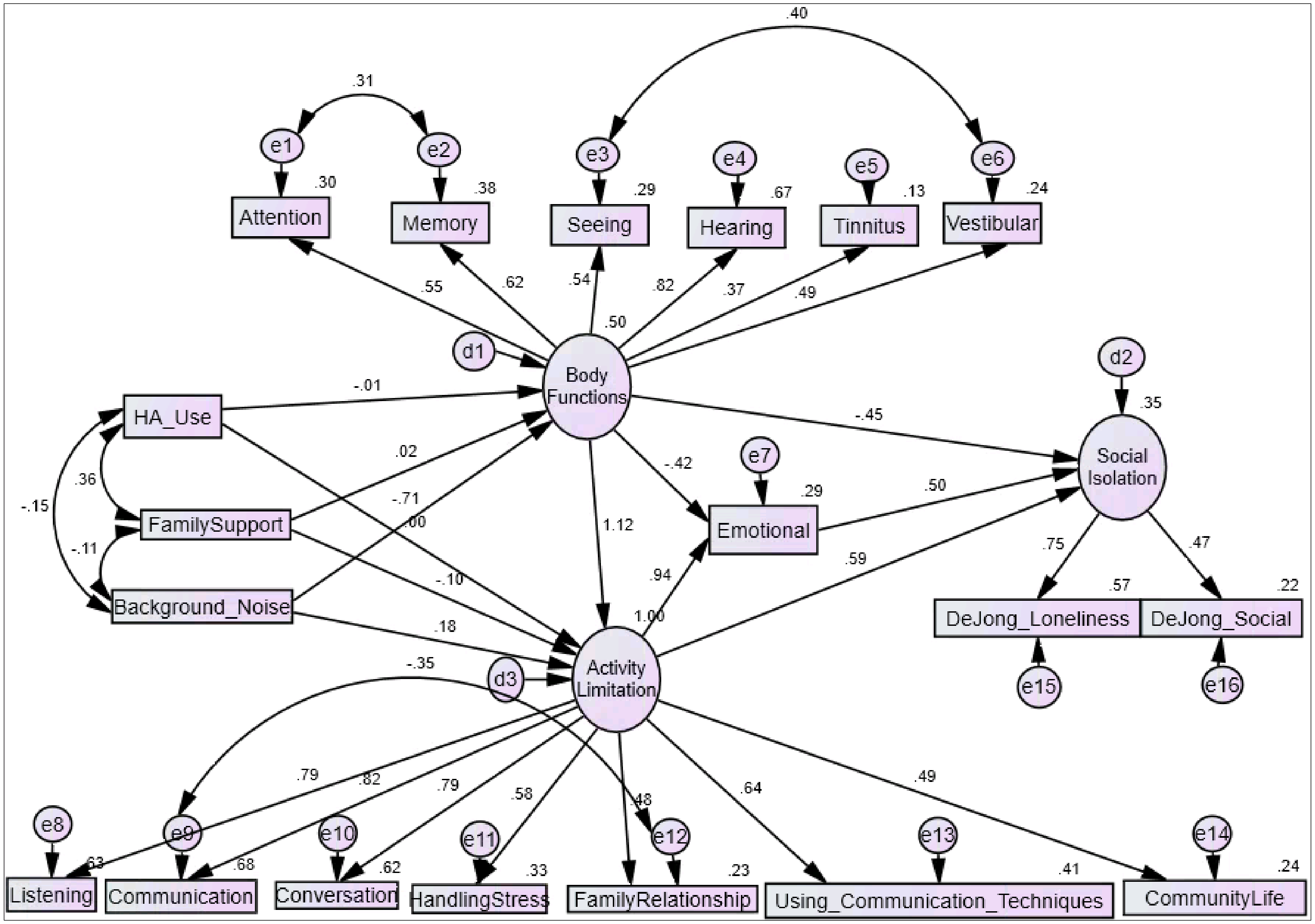

Figure 3-4. The SEM model of predicting social isolation from Self-Reported ICF Brief Core Set Scale for HL; The standardized coefficient (ß) on the direct arrows between model members and the R^2 (on the top of each variable or factor) across the 131participants

Table 3-14. The unstandardized regression and standardized weight, standard error estimates for the SEM Model of predicting social isolation from Self-Reported ICF Brief Core Set Scale for HL

Outcome measures (Indicators)		Regression Weights Estimates	B	ß	SE	P Value
Body Functions	<---	HA Use	-.002	-.005	.029	.950
Body Functions	<---	Family Support	.004	.016	.022	.845
Body Functions	<---	Background Noise	-.310	-.707	.053	***
Activity Limitation	<---	HA Use	.000	.000	.034	.993
Activity Limitation	<---	Family Support	-.043	-.097	.027	.108
Activity Limitation	<---	Background Noise	.134	.182	.063	.033
Activity Limitation	<---	Body Functions	1.882	1.124	.310	***
Emotional	<---	Body Functions	-.893	-.416	1.080	.408
Emotional	<---	Activity Limitation	1.208	.943	.652	.064
Social Isolation	<---	Body Functions	-1.289	-.455	.403	.001
Social Isolation	<---	Activity Limitation	1.000	.591		
Social Isolation	<---	Emotional	.658	.498	.159	***
DeJong Loneliness	<---	Social Isolation	1.000	.752		
DeJong Social	<---	Social Isolation	.623	.467	.191	.001
Family Relationship	<---	Activity Limitation	.382	.483	.070	***
Community Life	<---	Activity Limitation	.472	.486	.085	***
CommunicationTechniques	<---	Activity Limitation	1.063	.641	.139	***
Memory	<---	Body Functions	1.103	.617	.165	***
Seeing	<---	Body Functions	.906	.538	.179	***
Hearing	<---	Body Functions	1.937	.821	.294	***
Vestibular	<---	Body Functions	.788	.487	.168	***
Tinnitus	<---	Body Functions	1.038	.366	.278	***
Attention	<---	Body Functions	1.000	.550		
Communication	<---	Activity Limitation	.905	.824	.088	***
Conversation	<---	Activity Limitation	1.000	.789		
Handling Stress	<---	Activity Limitation	.650	.578	.096	***
Listening	<---	Activity Limitation	1.104	.794	.112	***

*** $P < .001$

Structure Equation Modeling (SEM) for the Standardized Outcome Measures with Depression

A SEM with *Maximum Likelihood method* was applied to evaluate if social isolation can be predicted from the standardized outcome measures according to the *a priori* model, which was presented in Figure 1-3. The model includes 15 outcome measures.

- *Body Functions:* Attention (BTA), Memory (DSB-V, DSB-L), Seeing (Snellen for distance), Hearing (BKB-SIN), Vestibular, (DHI) and Tinnitus (TFI).
- *Activity Limitations:* SSQ for (Listening, Communication, Conversation, Using communication techniques, and handling stress), and Family relationship.
- *Moderator/Mediation:* Emotion Function (GDS)
- *Environmental Factors:* HAs Use, Background Noise (ANL), and Family Support (LSNS-12).
  Personal Factors: Severity of HL (PTA)
- *Social Isolation:* two subscales of the LSIS-DJG

After modifying the model based on modification indices, the GOF statistics were (X^2 (90) = 126.203, P = 0.05; TLI = .90; CFI = .92; RMSEA=0.056, Pclose = 0.309). However, Bollen-Stine bootstrap was done to test the null hypothesis that the model is correct. Bollen-Stine bootstrap supported the fit of the model (P = 0.068). The SEM model with listing of standardized coefficient (ß) is presented in Figure 3-5.

Direct Effect

- Severity of HL associated with a significant negative effect on body functions (ß = - .75, P < 0.001) and with a significant negative effect on activity limitations (ß = -.40, P = 0.003).
- Social support associated with a significant positive effect on body functions (ß = .30, P < 0.001) and with a significant negative effect on activity limitations (ß = -.20, P = 0.007).
- Body Functions associated with a significant positive effect on activity limitations (ß = 73, P < 0.001), negative effect on depression (ß = - 1.1, P < 0.001), and negative effect on social isolation (ß = - 1.9, P < 0.001).
- Activity limitations associated with a significant positive effect on depression (ß = .72, P = 0.012).
- Depression associated with a significant positive effect on social isolation (ß = .382, P < 0.001). Further details are presented in Table 3-15.

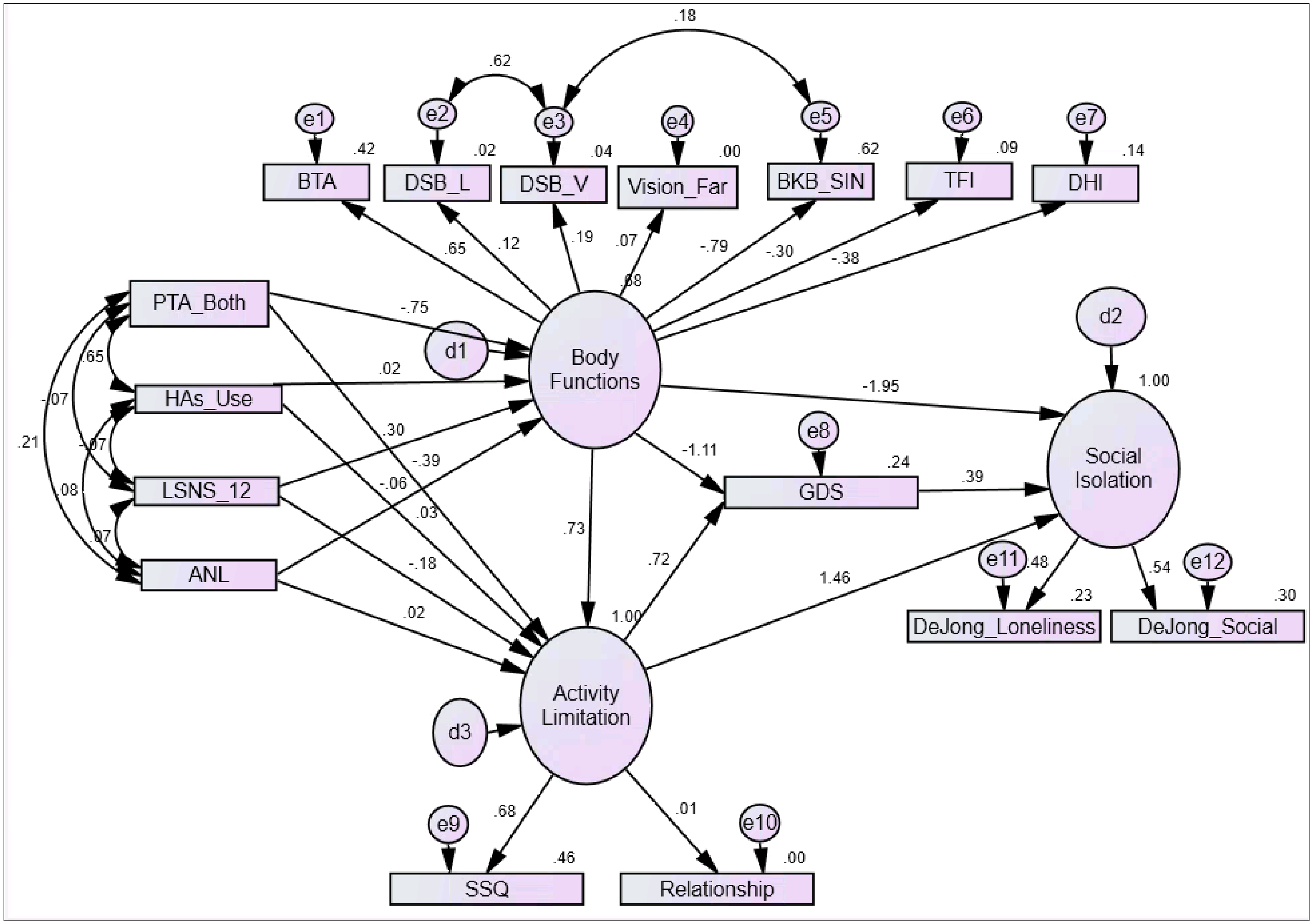

Figure 3-5. The SEM model of predicting social isolation from standardized outcome measures; the standardized coefficient (ß) on the direct arrows between model members and the R^2 (on the top of each variable or factor) across the 131participants

Table 3-15. The unstandardized regression and standardized weight, standard error estimates for the SEM Model of predicting social isolation from the standardized outcome measures with Depression (GDS)

Outcome measures (Indicators)			B	ß	SE	P Value
		Regression Weights Estimates				
Body Functions	<---	LSNS_12	.021	.302	.005	***
Body Functions	<---	PTA Both	-.028	-.748	.004	***
Body Functions	<---	ANL	-.009	-.061	.010	.371
Body Functions	<---	HAs Use	.029	.021	.118	.809
Activity Limitation	<---	LSNS_12	-.023	-.184	.009	.007
Activity Limitation	<---	ANL	.006	.020	.015	.707
Activity Limitation	<---	body Functions	1.327	.726	.331	***
Activity Limitation	<---	HAs Use	.067	.027	.171	.695
Activity Limitation	<---	PTA Both	-.027	-.388	.009	.003
GDS	<---	Body Functions	-1.700	-1.108	.505	***
GDS	<---	Activity Limitation	.606	.721	.242	.012
Social Isolation	<---	Body Functions	-2.445	-1.949	.381	***
Social Isolation	<---	Activity Limitation	1.000	1.456		
Social Isolation	<---	GDS	.317	.388	.119	.007
DSB_L	<---	Body Functions	.411	.125	.312	.188
DSB_V	<---	Body Functions	.633	.190	.322	.050
DeJong Loneliness	<---	Social Isolation	1.000	.477		
DeJong Social	<---	Social Isolation	1.181	.544	.254	***
Relationship	<---	Activity Limitation	.048	.011	.390	.901
SSQ	<---	Activity Limitation	1.000	.677		
BTA	<---	Body Functions	1.000	.646		
BKB_SIN	<---	Body Functions	-1.259	-.788	.174	***
TFI	<---	Body Functions	-.394	-.297	.128	.002
DHI	<---	Body Functions	-.521	-.379	.134	***
Vision Far	<---	Body Functions	.021	.067	.030	.477

*** *P < .001*

Structure Equation Modeling (SEM) for the Standardized Outcome Measures with Cognitive Decline

A SEM with *Maximum Likelihood method* was applied to evaluate if social isolation can be predicted from the standardized outcome measures according to the *a priori* model, which was presented in Figure 1-3. The model includes 15 outcome measures.

- *Body Functions:* Attention (BTA), Memory (DSB-V, DSB-L), Seeing (Snellen for distance), Hearing (BKB-SIN), Vestibular, (DHI) and Tinnitus (TFI).
- *Activity Limitations:* SSQ for (Listening, Communication, Conversation, Using communication techniques, and handling stress), and Family relationship.
- *Moderator/Mediation:* Cognitive Function (MoCA)
- *Environmental Factors:* HAs Use, Background Noise (ANL), and Family Support (LSNS-12).
  Personal Factors: Severity of HL (PTA)
- *Social Isolation:* two subscales of the LSIS-DJG

The GOF statistics were (X^2 (88) = 140.462, P = 0.000; TLI = .85; CFI = .90; RMSEA = 0.068, Pclose = 0.086). The SEM model with listing of standardized coefficient (ß) is presented in Figure 3-6.

Direct Effect

- Severity of HL associated with a significant negative effect on body functions (ß = - .75, P < 0.001) and with a significant negative effect on activity limitations (ß = -.40, P = 0.003).
- Social support associated with a significant positive effect on body functions (ß = .30, P < 0.001) and with a significant negative effect on activity limitations (ß = -.20, P = 0.007).
- Body Functions associated with a significant positive effect on activity limitations (ß = 73, P < 0.001), positive effect on cognitive (ß = .88, P = 0.008), and no effect on social isolation (ß = - 1.9, P > 0.05).Further details are presented in Table 3-16.

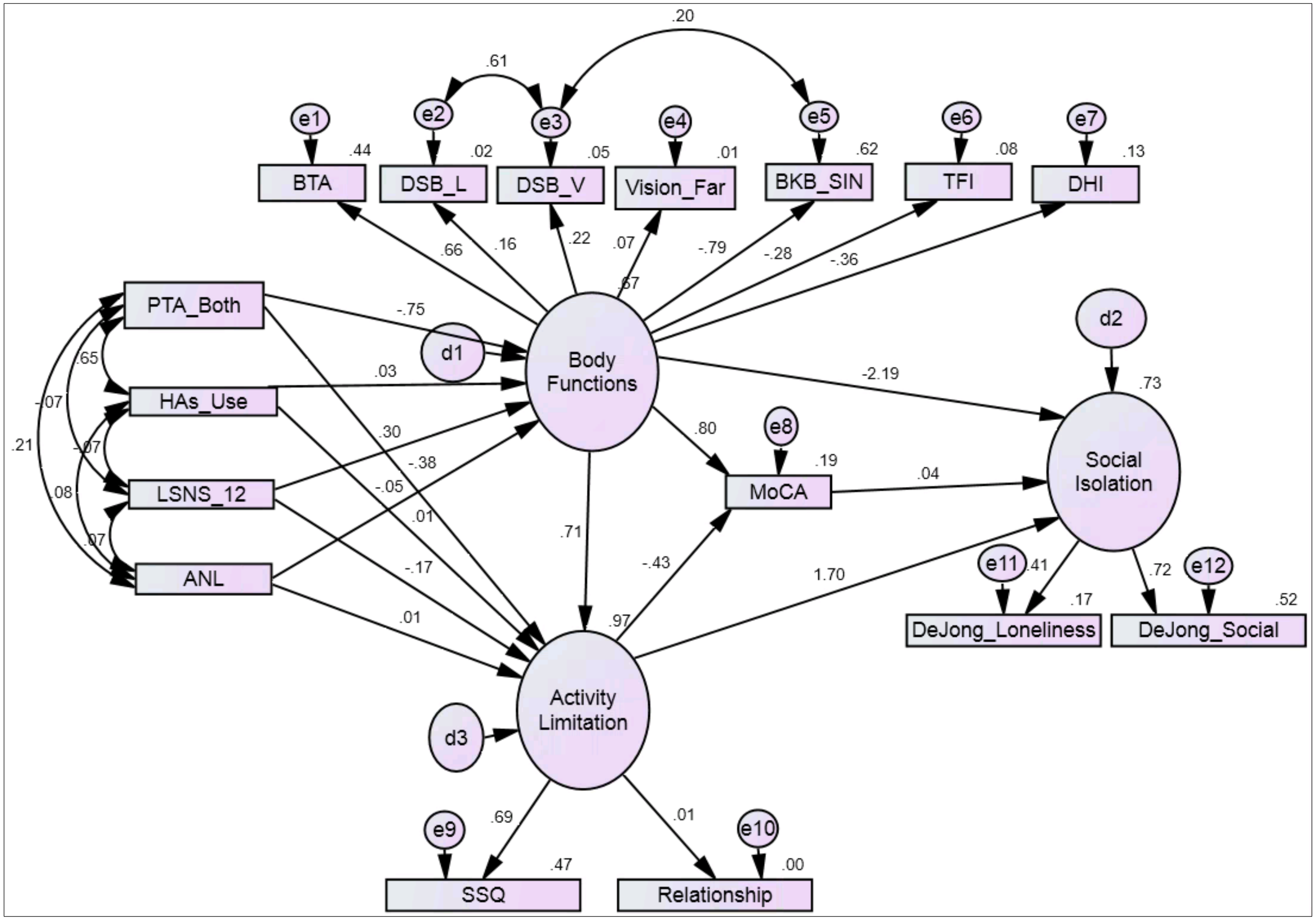

Figure 3-6. The SEM model of predicting social isolation from standardized outcome measures; the standardized coefficient (ß) on the direct arrows between model members and the R^2 (on the top of each variable or factor) across the 131participants

Table 3-16. The unstandardized regression and standardized weight, standard error estimates for the SEM Model of predicting social isolation from the standardized outcome measures with global cognitive functions (MoCA)

Outcome measures (Indicators)			Regression Weights Estimates B	ß	SE	P Value
Body Functions	<---	LSNS_12	.022	.303	.005	***
Body Functions	<---	PTA Both	-.029	-.752	.005	***
Body Functions	<---	ANL	-.008	-.051	.011	.450
Body Functions	<---	HAs Use	.047	.034	.121	.701
Activity Limitation	<---	LSNS_12	-.022	-.172	.009	.011
Activity Limitation	<---	ANL	.004	.013	.014	.804
Activity Limitation	<---	Body Functions	1.288	.713	.315	***
Activity Limitation	<---	HAs Use	.031	.013	.163	.847
Activity Limitation	<---	PTA Both	-.026	-.375	.009	.004
MoCA	<---	Activity Limitation	-.976	-.426	.642	.129
MoCA	<---	Body Functions	3.314	.800	1.255	.008
Social Isolation	<---	Body Functions	-2.328	-2.188	.361	***
Social Isolation	<---	Activity Limitation	1.000	1.697		
Social Isolation	<---	MoCA	.011	.044	.036	.749
DSB_L	<---	Body Functions	.507	.158	.305	.096
DSB_V	<---	Body Functions	.718	.222	.313	.022
DeJong Loneliness	<---	Social Isolation	1.000	.415		
DeJong Social	<---	Social Isolation	1.791	.721	.457	***
Relationship	<---	Activity Limitation	.045	.011	.391	.908
SSQ	<---	Activity Limitation	1.000	.687		
BTA	<---	Body Functions	1.000	.662		
BKB_SIN	<---	Body Functions	-1.226	-.786	.165	***
TFI	<---	Body Functions	-.360	-.277	.124	.004
DHI	<---	Body Functions	-.488	-.363	.129	***
Vision Far	<---	Body Functions	.023	.073	.029	.437

*** *P < .001*

Structure Equation Modeling (SEM): The integrated model

A SEM with *Maximum Likelihood method* was applied on the integrated model for social isolation prediction. This model had three factors named as: Auditory, Memory, and Socio-emotional Isolation. The SEM model with listing of standardized coefficient (ß) is presented in Figure 3-7.

- Auditory: PTA, BTA, BKN-SIN, SSQ, DHI, ANL, and TFI
- Cognition: DSB-V, DSB-L, and MoCA
- Social Isolation: LSIS-DJG and GDS
- Environmental Factors: HAs Use, and Family Support (LSNS-12)

A Chi-square test of independence supported the hypothesized model (X^2 (69) = 86.730, P = 0.073). The GOF statistics were (TLI = .95; CFI = .96; RMSEA = 0.044, Pclose = 0.604).

Direct effects on social isolation

- Social support and network size (LSNS-12) was significantly associated with a negative effect on socioemotional factor (ß = - 0.55, P < 0.001).

Indirect effects on social isolation

- HAs use was significantly associated with negative effect on Auditory factor (ß = - 0.66, P < 0.001). Auditory factor paly an intervening variable between HAs use and Socioemotional Isolation factor. Auditory factor was significantly associated with a negative effect on socioemotional factor (ß = - 0.24, P = 0.021).

- Social support and network size (LSNS-12) was significantly associated with a positive effect on global cognitive skills (MoCA) (ß = 0.21, P =0.009). Global cognitive skills (MoCA) paly an intervening variable between Social support and network size (LSNS-12) and Auditory factor (ß = 0.25, P = 0.007). Also, global cognitive skills (MoCA) paly an intervening variable between Memory and Auditory factors (ß = 0.47, P < 0.001). Further details are presented in Table 3-17.

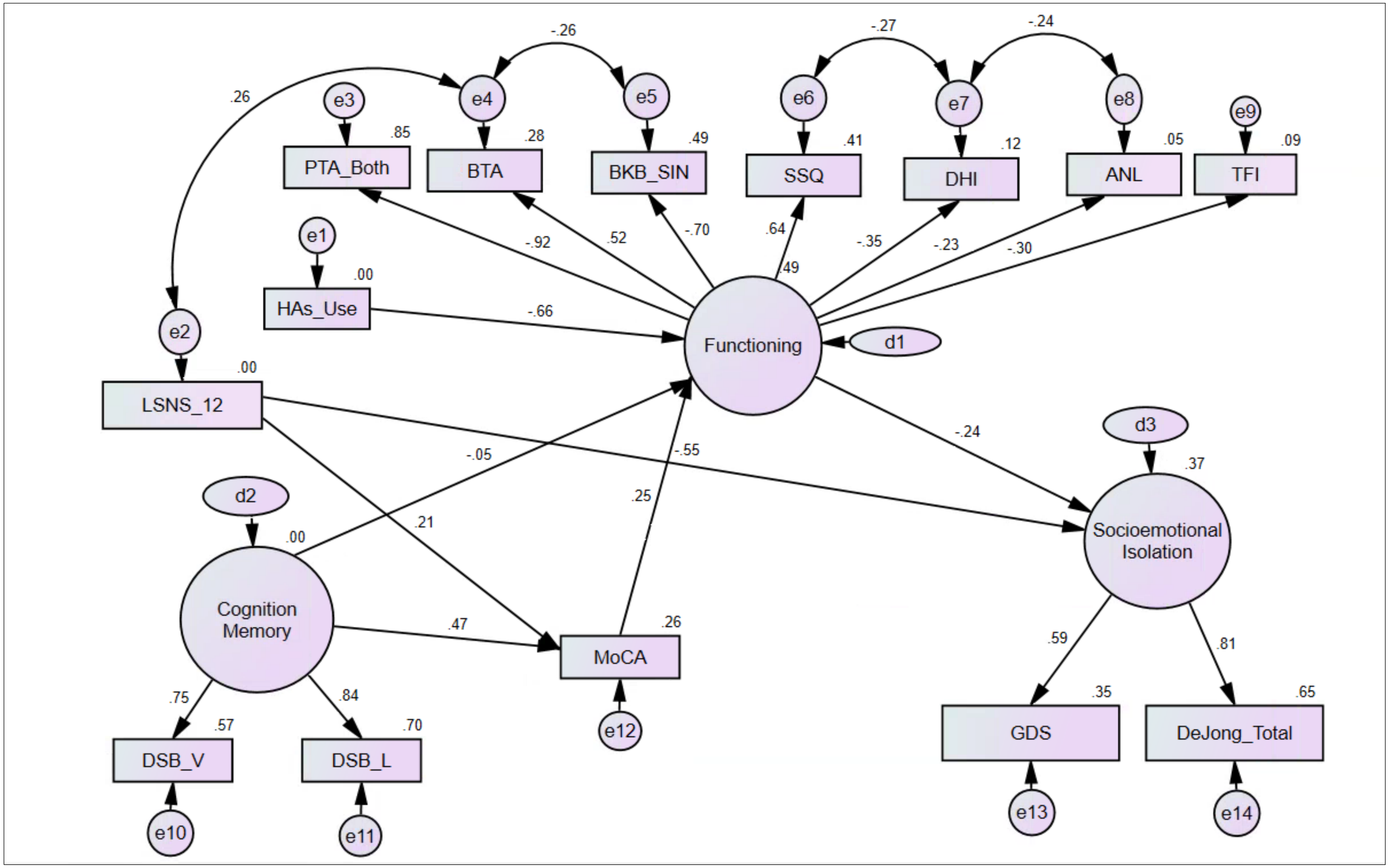

Figure 3-7. The integrated SEM with listing of standardized coefficient (ß) on the direct arrows between model members and the R^2 (on the top of each variable or factor) across the 131participants

Table 3-17. The unstandardized regression and standardized weight, standard error estimates for the integrated SEM Model

Regression Weights Estimates						
Outcome measures (Indicators)			B	ß	SE	P Value
MoCA	<---	LSNS_12	.060	.205	.023	.009
MoCA	<---	Cognition/Memory	.780	.466	.167	***
Auditory	<---	HAs Use	-.712	-.663	.126	***
Auditory	<---	Cognition/Memory	.047	.249	.017	.007
Auditory	<---	MoCA	-.014	-.045	.030	.631
Socioemotional Isolation	<---	Auditory	-1.092	-.240	.475	.021
Socioemotional Isolation	<---	LSNS_12	-.137	-.546	.025	***
DeJong Total	<---	Socioemotional Isolation	1.000	.806		
GDS	<---	Socioemotional Isolation	.250	.589	.057	***
DSB_V	<---	Cognition/Memory	1.000	.752		
BKB_SIN	<---	Auditory	-1.405	-.701	.212	***
DSB_L	<---	Cognition/Memory	1.100	.839	.222	***
SSQ	<---	Auditory	2.125	.643	.392	***
ANL	<---	Auditory	-1.887	-.227	.790	.017
DHI	<---	Auditory	-.604	-.347	.175	***
PTA Both	<---	Auditory	-30.330	-.921	4.819	***
BTA	<---	Auditory	1.000	.520		
TFI	<---	Auditory	-.506	-.302	.166	.002

*** $P < .001$

CHAPTER4
DISCUSSION

Validation

In this study, twenty-two ICF Brief Core Set categories were validated through a direct method of using a Self-Reported ICF Brief Core Set Scale for HL including:

- All the categories (seven categories) listed in the body functions domain.
- Eight of nine categories listed in the activity limitation and participation restriction domain.
- All the categories listed in the environmental factors.

The four categories of the body structure domain and the school education category from the activity limitation and participation restriction domain were not part of the Self-Report ICF Brief Core Set Scale for HL.

Additionally, 17-20 categories of the 22 categories were validated and verified through the indirect method using standardized outcome measures. Despite the difficulty in aligning the standardized outcome measures with ICF Brief Core Set categories, results obviously showed the significant correlation between individual's responses to the Self-Report ICF Brief Core Set Scale for HL and its related outcome measures.

Comparison between methods applied to validate ICF Brief Core Set for HL

A direct method of using a Self-Reported ICF Brief Core Set Scale for HL and an indirect method using standardized outcome measures were used in this study as compared with a researcher/clinician linking methodology used in the pilot studies. All methods showed almost identical patterns of four extracted factors.

First, the Self-Reported ICF Brief Core Set Scale for HL in its simple and initial version reveals that memory loss, hearing dysfunction, and inability to listen and communicate effectively were the major problems that limit and restrict participation in social interactions; while attention deficits, temperament and personality, emotional problems, and sensation of tinnitus had a moderate contribution to restricting social interaction. In regards to environmental factors, the majority of the participants reported noisy background as a barrier and the family/social support as a facilitator to social interaction; while the majority of HA users reported HAs use as a facilitator, some reported HAs use as a barrier.

The self-reported findings were verified by the significant correlation between the rating of ICF categories and the standardized outcome measures, but unexpectedly it highlighted the psychological and physical problems associated with dizziness sensation as measured by DHI.

Second, the Self-Reported ICF Brief Core Set Scale for HL factor analysis replicated the four-factor solution of older adult's functional performance that was found in the pilot studies' linking methodology and qualifier coding procedure (Alfakir, et al., 2015a). The overall variances explained by the application of the two methods were shown to be almost identical (55%, 60% respectively); however, there was a slight difference in the variances explained by each factor. In the linking methodology, auditory function was the major factor that explained variance in performance (32.3%), while in the direct method the non-auditory function was the major factor that explained the variances in performance (28.5%) followed by environmental factors (17.4%). Probably and not surprisingly, the deviation in variances was due to the focus on assessing hearing performance apart from other body systems and the surrounding environment, as highlighted in the introduction and pilot studies, whereas in the current study a more general introduction was given.

Third, the overall variances explained by the application of the standardized outcome measures were shown to be lower (<40%) than the two other methods (Self-Reported ICF Brief Core Set Scale for HL and the pilot studies' linking methodology and qualifier coding procedure). This indicates some difficulty in aligning the outcome measures with ICF Brief Core Set categories.

Fourth, the reliability of the ICF scale in the direct method (Self-Reported ICF Brief Core Set Scale for HL) was shown to be more robust and stronger compared to the linking and qualifier coding methodology. In the linking method, Cronbach's alpha coefficient for the items from the body functions and activities and participation scales was .88, while the Cronbach's alpha coefficient for the 22 items including the environmental items was .72. In the direct method, Cronbach's alpha coefficient for the items from the body functions and limitation/restriction scales was .89, while the Cronbach's alpha coefficient for the 26 items including the environmental items was .83. This difference could be due to the complexity of the environmental factors scale and/or the difficulty that faces researchers in classifying barriers versus facilitators for a patient instead of having the patient identify those by themselves. The excellent reliability results of the ICF scale, which is presented in the current study, is consistent with a study assessing validity of the ICF scales across 1,092 patients with 12 other chronic health conditions (Almansa, et al., 2011).

Finally, all methods supported the four-factor dimension. The theme of the four Factors almost identical, but how indicators clustered in each Factor slightly differs. For example, the CFA model for the Self-Reported ICF Brief Core Set Scale for HL (Figure 3-1) showed that indicators of Environmental Factor was fairly correlated with Auditory Factor ($r = .2$). While in the CFA model for standardized outcome measure, indictors of Environmental Factor were impeded in Auditory and Psychosocial factor leading to a strong relationship between these two factors ($r = .55$) as shown in Figure 3-3. This could be explained by the fact that most audiologic test battery considers background when measuring auditory function and hearing disability but none consider the effect of social structure and family support and other environmental factors. Further reason could be due to difference between scales as the ICF scale for environmental factors represents two aspects, facilitator and barrier, which are not common in standardized outcome measures. Another example, the CFA model for the Self-Reported ICF Brief Core Set Scale for HL (Figure 3-1) showed that vestibular and seeing items were clustered with non-auditory factor that includes cognition, emotional, and other activity limitations such as handling stress and participation in community life; while vestibular and seeing functions were clustered within other auditory indicators. This could be explained by the vague definition of dizziness sensation that may include psychological and physical effect of vestibular and postural deficits.

The dimensions of the ICF Brief Core Set for HL (CFA Models)

"Without functional status information, the researchers, policymakers, and others who are already using administrative data have at best a rough idea of how people, individually and collectively, are doing and at worst they are making erroneous assumptions and decisions"

(National Committee on Vital and Health Statistics, 2001)

Interestingly, all methods supported the four dimensions that explain poor social interaction performance in older adults with hearing difficulties. Both CFA models (Figure 3-1, 3-3) highlighted a need to evaluate the person as a whole and not just the auditory system in order to develop rehabilitation plans. The main recommendation of this study is that four dimensions of ICF Brief Core Set for HL are necessary to be measured. The advantage of using the Self-Reported ICF Brief Core Set Scale for HL has two implications. First, it allows the clinician or researcher to translate functional information into a universal language, no matter, the method used to obtain it. Second, it could be used as an outcome measure to better understand performance or behavior, monitor changes in performance, and integrate into AR plans.

Outcome measures form a central component in AR programs. They are used to indicate the major problems challenging individuals with HL, contribute to the process of setting goals, and monitoring treatment effectiveness. In audiology clinical settings, the use of multiple outcome measures could be impractical in terms of the assessment time especially in elderly populations in term of reliability. For example, the overestimate might affect the self-reported outcome measures of perceived hearing disability (e.g. Eriksson-Mangold & Carlesson, 1991). While the underestimate tends to cause delay in their seeking help for a potential disorder until they cannot communicate even in the best listening communication (e.g. Smith & Kricos, 2003). In this study, the high and significant correlation between the Self-Reported ICF Brief Core Set for HL and the standardized outcome measurements indicates that the use of multiple outcome measures is practical in terms of time and reliability. This could be done by using the Self-Reported ICF Brief Core Set for HL as a screening tool followed by the standardized outcome measures. However, further improvement is required for the some items in the current version of the Self-Reported ICF Brief Core Set for HL and further studies are needed to explore the best standardized outcome measures that represent the ICF categories. For example, Big Five Personality Inventory (BFPI) found to be not highly correlated with Temperament and Personality category; this indicating that either single question was not clear or the BFPI was not the best measure.

According to the presented CFA models, all categories and their related outcome measurers were significant indicators except for the vision in the CFA model for the standardized outcome measures; however, it showed to be an important part of the model due to close relationship with vestibular function or dizziness sensation. Probably because, almost the majority of participants had have a corrected vision when they evaluated.

One of the unexpected findings in the CFA model of the standardized outcome measure was the correlation between the dizziness (DHI), listening ability (SSQ), and noise background (ANL). Undoubtedly, effective listening tends to be fostered when people demonstrate a relaxed alertness with the body leaning slightly forward, facing the other speaker or communication partner, maintaining postural balance, and situating themselves at an appropriate distance from speaker. Given the high probability of HL to be associated with dizziness or probability of age-related impairment in physical movement, it is not surprisingly that vestibular category was clustered in non-auditory functions factor (Figure 3-1) and DHI outcome measure was grouped within sensory factor (Figure 3-3). Vestibular sensation triggered by any action could be taken to improve speech recognition. Ross (1992) found that any trivial change in distance can significantly reduce the received level of speech as sound energy spreads and dissipates throughout meeting areas. Modifying situations requires the integration of functional connectivity between auditory- vestibular-visual systems and cognitive abilities. When the discrepancy in sensory information processing occurs, the internal representation becomes inaccurate and vague; hence, emotion, such as anxiety and cognitive performance, such as poor attention suggested to be highly influenced (Smith, et al., (1997). This findings was reflected on the strong relationship between sensory, cognitive, and socioemotional performances.

The role of the auditory-visual- cognitive in managing challenging situations was reported in several studies. For example, the integration of auditory-visual input with cognitive functions lessened the noise distraction in the elderly as reported by (Kricos & Holmes, 1996; Tye-Murray, et al., 2008; Feld & Sommers, 2009). Several studies highlighted the relationship between vestibular deficits, cognitive decline, and emotion functions. For example, the animal studies significantly showed that rats without vestibular lesions perform better in cognitive tasks than rats with vestibular lesions (Smith & Zheng, 2013). Further studies, showed that vestibular information provided by vestibular system in the vistibulo-ocular and vestibule-spinal reflexes and in the ascending pathways to the limbic system and neocortex is required for an accurate internal representation of the relationship between the self and the spatial environment (Angelaki, et al., 2009). This may provide further support of the involvement of Dizziness in limiting effective listening and/or restricting older adults with and without HL to participate in social interaction and in community life.

Tinnitus is often related to hearing loss, but not all, hearing impaired people have tinnitus. It was suggested that for tinnitus to develop, one has to have one of two conditions or both: a HL or a chronic neuro-psychological overloading (Wagenaar, et al., 2010). Tinnitus is another significant indicator may disrupt speech in noise perception, cognitive, and emotion. This result supported by the recent findings that tinnitus leads to poor speech understanding and communicational problems (Miller, 2009; Araujo, et al., 2015). Further studies supported that tinnitus directly impairs cognitive performance, namely working memory and attention (Hallam, et al., 2004; Stevens, et al., 2007) or indirectly alter emotional function (Holmes & Padgham, 2009).

Dysfunctional cognitive performance was obvious in the presented data as measured by global cognitive (MoCA), attention (BTA), and working memory (DSB-L, DSB-V) tests. The CFA model demonstrated the tight relation between auditory divided attention and speech in noise perception and the tight relation between working memory via both modalities and cognitive skills. Considering that including attentional and working memory outcome measures could be considered out of audiologist's scope of practice, screening for cognitive skills should to be significantly helpful. MoCA was designed to assist in detection of mild cognitive impairment, which on one hand, may help to explain poor performance of speech in noise perception, and on the other hand, may help to plan for further assessments by referrals to other health professionals. This result answers the question “To screen, or not to screen” (Anderson & Kraus, 2013) and further supports the preliminary study results (Alfakir, et al, 2015b).

The CFA models further highlighted the role of family relationships. Results of the current study highlighted the effect of poor family relationship in decreasing participation restriction. Our results supported a study which found positive marital or family relationships were negatively associated with loneliness (Hawkley, et al., 2008). Further, this result is consistent with our preliminary study (Alfakir, et al, 2015) and with Scarinci, et al., (2009) model. Despite the moderate correlation between the family relationship category and Relationship Assessment Scale (RAS), our results extend the findings of Scarinci and collegues. Both CFA models highlighted that cognitive, sensory and socioemotional performance may contribute to the direct or indirect effect of family relationship. Also, these findings provide further direction for the appropriate outcome measure to replace the RAS, such as Self-Assessment of Communication and the Significant Other Assessment of Communication which were developed by Schow and Nerbonne in 1982.

Implications

In brief, the CFA models speak to the need to address the four dimensions (Sensory, Cognitive, Psychosocial, and Family relationships) provided by the ICF Brief Core Set for HL when developing treatment plans for patients complaining of listening difficulties, including mild HL.

Given the attention to all epidemiologic and longitudinal studies of age-related changes in health, a tool like the ICF Core Sets for HL will assist professionals implementing an integrated perspective in hearing health care. The ICF Core Set for HL defines, in theory, all categories that are relevant to the functioning of patients with HL and, consequently, what to address and assess among patients with and without HL. It provides a comprehensive, multidimensional perspective. Application of the Core Sets for HL can ensure consistency in terminology across disciplines, improve inter and intra-professional communication, and facilitate multidisciplinary responsibility. Therefore, the ICF Core Set categories can be regarded as a common standard from which different professionals can start their assessments and interventions. The functioning profile of the patient that can be created can be used as a reference for monitoring the patient during follow-up visits. Considering the ICF as a screening outcome measure could be particularly important for establishing baseline information and systematically monitoring of functional performance in older adults with listening difficulties over time.

The CFA models reported in this study provide further insight into the course of hearing disability, socio-emotional health, and its related environmental factors in a representative cohort of one-hundred and thirty one older adults. This suggest the possibility of social isolation being predicted by the by ICF Brief Core Set using the standardized outcome measures. More details will be discussed in in the section below.

Application

Hearing Disability and Socio-Emotional Isolation in an Aging Population

A barrier to communication is something that keeps meaning from meeting. Meaning barriers exist between all people, making communication much more difficult than most people seem to realize. It is false to assume that if one can talk he/she can communicate. Because so much of our education misleads people into thinking that communication is easier than it is, they become discouraged and give up when they run into difficulty. Because they do not understand the nature of the problem, they do not know what to do. The wonder is not that communicating is as difficult as it is, but that it occurs as much as it does.

Reuel Howe (1963)

The prediction models (SEM) which are illustrated in Figure 3-4, 3-5, and 3-6 supported the a priori model, and clearly highlighted the complexity of what is involved in causing social isolation in older adults with HL and/or listening difficulties. The prediction model (Figure 3-4), which was created from the Self-Reported ICF Brief Core Set Scale for HL, showed to be useful in predicting social isolation. However, further improvement is required for the initial version. This model highlighted the effect of the noisy environment on poor functional performance including daily activity limitations and the moderator effect of emotion function on social isolation. The prediction model (Figure 3-5), which was created from the standardized outcome measures highlighted the mediation effect of depression (GDS) on social isolation. While the prediction model (Figure 3-6), which was created from the standardized outcome measures highlighted the mediation effect of cognitive skills (MoCA) on social isolation. Via this information we were able to integrate the a priori model which was presented in Figure 3-7.

The integrated model showed that social isolation in older adults with and without HL could be a maladaptive strategy for dealing with effortful listening or a psychological reaction if it is combined with depression and associated with lack of support from family members and friends. In other words, social isolation could be a meaningful psychological reaction when older adults become discouraged and give up when running into poor listening conditions that degrade speech understanding. In contrast, social isolation could be a psychological disorder when functional connectivity decreases and interacts with environmental factors and decline in cognitive skills and lower working memory capacity.

The integrated model demonstrated that effortful listening is the product of inability to process degraded speech (BKB-SIN), which depends critically on the ability to divide attention (BTA), ease of listening (SSQ), physical attending (DHI), presence of tinnitus (TFI), and inability to tolerate background noise (ANL). This assumption is valid among non HAs users and HAs users who reported that HAs functions (clarity and loudness) were a barrier. Results showed that the interaction between poor functional performance and HAs use and few benefits can significantly lead to social isolation. The implication of these findings may explain why listening and communication difficulties and social isolation still are the most common complaints among older listeners with both treated and untreated HL (Humes, et al., 2006; Mick, et al., 2014; Dawes, et al., 2015).

In contrast, the integrated model highlights the dynamic relationship between functioning or effortful listening, working memory capacity (DSB-V and DSB-L), and global cognitive function (MoCA) and its contribution to turning limitations into restriction or isolation. Further, it highlights the effect of global cognitive skills on functioning or effortful listening and a need to screen for cognitive decline as recommended by researchers. Our study supports a study found a significant correlation between working memory performance and sentence repetition and processing (Small, et al., 2000). Further, it supports the effect of cognitive decline as a psychological barrier that leads to social isolation (Havens et al., 2004) and aligns with the working group researchers whom outlined the clinical criteria that must be used to differentiate between normal cognition and MCI and between dementia (Albert, et al., 2011). These criteria are: 1. Concern regarding a change in cognition. 2. Impairment in one or more cognitive domain. 3. Preservation of independence in functional abilities. 4. No evidence of a significant impairment in social functioning.

To conceptualize the overall findings and its relation with socioemotional isolation, first we need to understand the nature of effortful listening and its relationship to mental illness. Although depression and loneliness are aversive behaviors or uncomfortable states; they are in many ways opposites. Loneliness in its positive nature is a warning to initiate change in an uncomfortable condition. On the other hand, depression makes individuals apathetic (Cacioppo & Patrick, 2008). In other words, while loneliness urges individuals to move forward to adjust for communication breakdown, depression holds individuals back. But when both converge, it can lead to passive coping. However, this does not always lead to effective action, and it may instead lead to learned helplessness. Within the struggle to self-regulate, according to Cacioppo & Patrick, loneliness and depression are at their core a closely linked push and pull. This facilitates a simple, two part decision – approach or withdraw – repeated endlessly as the individual confronts every stimulus. Approach or withdraw are the two common and shared behaviors in normal listeners and HL listeners that may rise in noisy environments.

Several studies conceptualized loneliness as perceived social isolation and refer to the negative emotions resulting from a discrepancy between individuals' desired and present quality and/or quantity of social relationships (Cacioppo & Patrick, 2008). In our preliminary studies we found that even with HL and perceived handicap individuals with HL can still strive to maintain the normal social interaction by using adaptive or maladaptive compensatory strategies (Alfakir & Holmes, in progress). Negative emotional reactions, such as feeling lonely or depressed are maladaptive strategies reported by older adults with HL. Thus, it was suggested that the effect of maladaptive strategies may strongly contribute to social isolation more than the effect of the HL itself. Yet, reasons beyond this maladaptive reaction were not clear. A possible explanation for this reaction in older adults with HL, according to our model *is "listening difficulties in older adults can induce stress, leading their subconscious in a fight or flight mode. The presence of depression may make fearful or anxious thoughts become louder (push and pull assumption). The presence of dizziness and inability to change body position may make them feel either threatened or unsafe in some way. At this time, performance of cognitive functions, family relationship/support, and availability of environmental resources may enhance or reduce socio-emotional performance."* For example, the HAs use offers an opportunity to enhance audibility, while the appearance of dizziness demands caution and fear of falling or unsteadiness, whereas presence of tinnitus demands caution of speech perception clarity. With HL and dizziness tasks or tinnitus ignorance, mental attending and effective listening become more challenging and may be independent from working memory.

The suggested mechanism to explain this relationship is that as the auditory system is important for auditory localization, the vestibular system is essential for path navigation; and both play an important role in directing attention toward different sources. This information is used to make decision, compute and action plan, and finally execute a movement. With probability of the sensory losses to be associated with cognitive decline and negatively interaction with surrounding environments, this does not allow one to stop and think or to collect information, build a complete knowledge of one's surrounding, and act. Deficiencies in the way the brain coordinates and synchronizes activity amongst different regions may account for the deficiency in executive functions including divided attention and working memory" In other words, when individuals with HL and vestibular disorders exhibit reduced functional, the spatial function brain regions could contribute to performance deficits that lead to social isolation".

The integrated model tells us that as the HAs use was obvious on decreasing/increasing effortful listening and enhancing/reducing participation, the role of family and friends support was more obvious on cognitive and mental health. In part it has strong and direct effects on social isolation or indirect effects through the moderator/mediation effect of cognition decline and depression. These findings are consistent with studies that linked social support with successful ageing. For example, perceived social support found to be was a strongly correlated with psychological distress associated with HL (Turner, et al., 1983), with HAs satisfaction and participation in group AR classes (Preminger, 2003), with motivation to help-seeking and conversation facilitation (Lockey, et al., 2010), and with later life cognition (Gow, et al., 2007). However, addressing the social support and elderly's social structure in AR is uncommon. Thus, in the meantime, it is highly recommended for hearing care providers to assess availability of social support in addition to HAs.

In brief, while non-HAs use, may turn auditory limitations into restriction, lower social support may turn hearing disability into restriction by mitigating emotional distress, cognitive function, and mental illness. In other words, as HAs facilitates bottom-up processing, social support facilitates top-down processing.

Implications

The overall models highlighted the difficulties separating changes in sensory inputs and poor cognitive performance from socio-emotional disorders. Obviously, defining predictors that may lead to social isolation seems difficult and complex. Social isolation management requires an integrative approach including the accessibility to the HATs in surrounding environments, occupational therapy, and application of modern cognitive neuroscience to health-related issues.

It is important to highlight that treating any disorder should go further and beyond disorder itself. For older adults with hearing difficulties we need to target reduced functional performance in order to enhance social interaction which is the overall goal of AR services.

Study Conclusions

A direct method of using a Self-Reported ICF Brief Core Set Scale for HL and an indirect method using standardized outcome measures were used in this study as compared with a researcher/clinician linking methodology used in the pilot studies. All methods were shown to be useful and ready for use in clinical practice. The Self-Reported ICF Brief Core Set Scale for HL combined with Montreal Cognitive assessment are a usefulness screening tools to be used in audiology clinical practice to predict whom at risk for social isolation and dementia.

Social isolation is the product of several interactions and not a certain consequence of growing older, but it is mitigated by decline in cognitive functions and health disorders. It is not difficult to find evidence in the literature that socio-emotional isolation is a risk factor for cognitive decline and Alzheimer's disorder, but it is difficult to find evidence that shows the reverse direction. As hypothesized, social isolation would be a consequence rather than cause of cognitive decline and HL.

Limitations of the study and Future direction

This study is unique in its approach and results; however, the study has some limitations. First, the Self-Report ICF Brief Core Set Scale for HL, in it is initial version, has shown to be useful and appropriate to be used as a screening tool. Yet, some categories [Temperament and Personality (b.126) and Sensation associated with vestibular function (b.240) were found to be not clearly defined in its written form, needing further improvement for the Self-Report ICF Brief Core Set Scale for HL.

Second, the current version of the ICF Brief Core Set has 27 categories; seven are part of the environmental factors. In this study, we were able to include and study the effect of support from immediate family and friends. Further studies are needed to include the effect family and social attitude and other environmental items.

Third, the Self-Report ICF Brief Core Set Scale for HL was shown to be useful in validating ICF Brief Core Set. The use of this method is recommended to validate the ICF Comprehensive Core Set in a large sample size. Being able to validate the Comprehensive Core Set for HL is suggested to optimize the Brief Core Set.

Fourth, the Dizziness Handicap Inventory questionnaire highlighted a relationship between sensory-motor and listening; however, the role of the audio-vestibular complex and its contribution to listening difficulties were not clear and requires further investigations.

Finally, our study was completed on a sample of nonclinical older adults, fairly well educated, and of a higher social economic status. Further studies should be done with clinical populations, and different age group, communities, and cultures.

APPENDIX A
ARTICLE 1

Informa healthcare

International Journal of Audiology 2015; Early Online: 1–8

International Journal of Audiology

Review Article

Functional performance in older adults with hearing loss: Application of the International Classification of Functioning brief core set for hearing loss: A pilot study

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The British Society of Audiology
The International Society of Audiology
NAS Nordic Audiological Society

Abstract

Objectives: The beta version of the International Classification of Functioning, Disability, and Health (ICF) brief core set for hearing loss in adults was developed and recommended to be validated through the audiologic rehabilitation clinical practice. The aims of this pilot study were to validate the ICF brief core set by examining the dimensions of hearing performance measures used in a standard care university clinic specializing in amplification, and seeing if those dimensions support the structure provided by the core set. *Design:* ICF linking, classification, and qualifier coding procedures were applied on a data set identified from clinical records and two paper-pencil questionnaires; and completed by consensus of two experienced audiologists. *Study sample:* Forty-nine participants were recruited from an out-patient population at an audiology clinic. *Results:* Eighteen of 27 items from the brief core set were able to be linked and validated. Four factors were identified, and confirmed the structure of ICF concept: Auditory function, Other functions, Activities/contextual interaction, and Third-party disability. Further, three predictors significantly discriminated performance in 28 participants: the use of hearing assistive devices, speech-reading, and active social life. *Conclusions:* The ICF brief core set is a valuable tool for use in audiologic rehabilitation clinical practice and research design.

Key Words: World Health Organization's International Classification of Functioning; Disability and Health; brief core set for hearing loss; hearing-aid outcome measures

Hearing loss (HL) represents a broad category of normal age-related changes that lead to diminished quality of life in adults over 55 years old. HL is the third most prevalent chronic disorder after arthritis and hypertension (Cruickshanks et al, 2010). HL is associated with tinnitus and balance dysfunctions, vision, cognitive, emotional impairments, and personality change. Such impairments are followed by limitations of activities in daily living (e.g. listening, communication) and restrictions in social life participation (National Council on the Aging, 2011).

Outcome measures of auditory function form a central component in audiologic rehabilitation (AR) programs. They are used to indicate the major problems challenging individuals with HL, contribute to the process of setting goals, and monitoring treatment effectiveness. In AR programs, numerous outcome measures are used that differ in type, quantity, and quality. These usually fall in two categories: objective and subjective performance measures. The traditional objective outcome measures include pure-tone audiometry to examine the impairment-related ear structure and speech audiometry measures to evaluate auditory function. Subjective self-report measures are used to indicate disability and handicap, benefits and use of hearing assistive technologies (HATs), benefits and quality of well-being life. These measures may serve as a starting point in the diagnosis or the assessment, but may not be ideal for rehabilitation where functioning and health is not primarily an outcome. This has led to several debates about how best to maximize clinical outcome measures within AR programs.

Humes (1999) recommended that hearing aid (HA) outcome measures should be a multidimensional construct that include at least one measure of speech recognition performance, one or more speech perception tests, and one or two subjective measures of sound quality or listening effort, benefit, satisfaction, or use. Wilkerson (2000) discussed the implications of the ecological approach and the World Health Organization's (WHO) international classification of impairments, disabilities, and handicaps framework for AR programs that looks to the whole person to be able to answer the question "*Does the rehabilitation work to improve the individual ability to participate in social events?*" Wilkerson concluded that AR outcome measures are consistent with the trends in the rehabilitation

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APPENDIX B
ARTICLE 2

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Review Article | Open Access

How can the Success Post Cochlear Implant be Measured or Defined in Older Adults? Implications of the International Classification of Functioning Brief Core Set for Hearing Loss

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Abstract

Objectives: Hearing loss (HL) represents a broad category of normal age-related changes that lead to several diminished domains of functions including sensory, cognition, emotional, social, and overall quality of life which may increase loss of independence. Despite the enormous success of cochlear implantation (CI) to treat profound HL in older adults, the individual differences in outcome measures due to several functional deteriorations raise an important question: "How can the success post-CI be measured or defined in older adults?" In 2012, the international classification of functioning (ICF) brief core set of hearing loss was designed to provide clinicians an international standard of what to assess and report on persons with HL. The main objective of this pilot study is to demonstrate success post-CI in older adults using the ICF concepts and brief core set of HL and to discuss what is needed in order to meet the functional decline in older adult CI users.

Design: Case studies of nine older adult CI users were analyzed using single-subject analysis.

Results: Twenty of 27 ICF brief core set items were linked to from the study materials. The ICF analysis clearly demonstrated the individual differences in outcome measures. One case of nine met the criteria of the ICF.

Conclusions: The ICF is a valuable instrumental tool that can be used in CI clinics to optimize audiologic rehabilitation services provided to the aging population. Undoubtedly, there is a need to re-define success post CI in the elderly according to the ICF concept.

Keywords: World Health Organization's international classification of functioning; Disability and health; Brief core set for hearing loss; Hearing loss outcome measure; Cognitive outcome measure; Cochlear implant in older adults

Abbreviations:

WHO: World Health Organization; ICF: International Classification of Functioning, Disability and Health; AR: Audiologic Rehabilitation; HHIE-S: Hearing Handicap Inventory for Elderly-Screening version; WHODAS 2.0: WHO Disability Assessment version 2; MoCA: Montréal Cognition assessment; MCI: Mild Cognitive Impairment, AD: Alzheimer Disorder; HL: Hearing loss; CI: Cochlear Implant

Introduction

A cochlear implant (CI) is an electrical device that is placed in the inner ear to provide auditory information for individuals who cannot obtain sufficient benefit with regards to speech perception from hearing aids (HAs) to rely on listening for communication. CI is an accepted rehabilitative device used to manage hearing loss (HL) worldwide. Commonly, it is the most effective treatment method for individuals with severe to profound sensorineural HL in all ages. The literature shows that the ability to distinguish, hear, and follow conversations, use the telephone, and listen to the radio and television at acceptable levels, when compared to the individual's difficulty prior to obtaining the CI, was improved in older adult CI recipients [1]. However, little is known about the communication performance in real world [2]. Further, the CI can enhance the individual's quality of life, reduce limitations and enhance participation in community life [3-5]. However, poor speech perception in noise is the most common complaint among older adults even with the use cochlear implants [6,7] Studies found that memory and attention functions, neural processing, and life experience factors had the biggest contributions to hearing function (speech-in-noise performance) [8-10]. With the growing interest to discover the relationship between auditory and cognitive systems screening for cognitive function in individuals with HL was recommended. In 2015 Mosnier et al. evaluated 94 older adults with profound post-lingual HL pre- and 12 months post-CI. Results showed that the global cognitive function scores were improved [11], remained stable or declined after one year of cochlear implantation; however, it is still unclear why there is a variation in cognitive function scores post-CI. Indeed, this variation highlighted the role of individual differences in audiologic rehabilitation (AR) outcome measures and other hidden factors.

Aside from specific diseases, HL represents a broad category of normal age-related changes that lead to several diminished domains of function including sensory, cognition, emotional, social, and overall quality of life which may increase loss of independence [12]. A recent longitudinal study concerning aging, the auditory system, and

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APPENDIX C
ARTICLE 3

Article

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Evaluation of Speech Perception via the Use of Hearing Loops and Telecoils

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Abstract

A cross-sectional, experimental, and randomized repeated-measures design study was used to examine the objective and subjective value of telecoil and hearing loop systems. Word recognition and speech perception were tested in 12 older adult hearing aid users using the telecoil and microphone inputs in quiet and noise conditions. Participants were asked to subjectively rate cognitive listening effort and self-confidence for each condition. Significant improvement in speech perception with the telecoil over microphone input in both quiet and noise was found along with significantly less reported cognitive listening effort and high self-confidence. The use of telecoils with hearing aids should be recommended for older adults with hearing loss.

Keywords

telecoil, microphone, hearing loops, hearing loss, speech perception in quiet and noise, cognition, self-confidence

Introduction

According to the American Speech-Language-Hearing Association (ASHA), hearing is defined as the process of collecting, attending to, and understanding sound from the environment (ASHA, 2012). There is no doubt that our hearing sensory system is a primary window to discover the world. Throughout our lives, hearing input provides us with an incredible rich and nuanced source of information. Hearing function, along with other sensory systems, emotional and cognition functions, is critical for the aging population to participate in day-to-day interactions and social activities.

As we age, hearing acuity for high frequency sounds deteriorates, leading to hearing loss (HL) or what is known as a presbycusis condition. HL is the third most prevalent chronic disorder after arthritis and hypertension (Cruickshanks et al., 1998; Mitchell et al., 2011; National Center for Health Statistics, 1989). The global estimates of mild HL (≥40 dB) in adults above 55 years of age range from 15% to 25% (World Health Organization, 2012). Another global estimate is the vast increase in the numbers of aging people 65 years and above between 2010 and 2050. Considering both estimates together, hearing impairment will increasingly affect older adults in the future in all regions. The primary consequence of the HL significantly affects several aspects of the elderly's everyday life such as speech perception in noisy environments, cognitive listening effort, communication abilities, self-confidence, and emotional and social functions (Hallberg, Hallberg, & Kramer, 2007; Mick, Kawachi, & Lin, 2014; National Council on Aging, 1999).

Notably, in daily life activities, the ability to hear and listen depends on the integrity of the auditory neural system from the ascending auditory pathways to higher order functions and vice versa. As the auditory system ages, it indirectly develops central changes induced by peripheral lesions (degeneration of spiral ganglion) leading to a reduced input into the central auditory system. Also, the auditory system undergoes direct morphological and physiological changes induced by the biological effect of aging associated with a decline in central neural auditory processing ability. This leads to loss of speech understanding greater than would be expected from the audiometric thresholds and decreased ability to localize sounds and detect signals in noise. Therefore, central auditory changes in the aging population can essentially be classified into two major types. The first type is referred to as *the central effects of peripheral pathology*, which presents with changes in the cochlear nucleus driven by the decline of peripheral cochlear inputs that occur with age, typically starting with HL at high frequencies. The second type is referred

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APPENDIX D
SAMPLE OF OUTCOME MEASURES

Self-Reported ICF Brief Core Set for HL

Part 1: Body Functions

- If you think about your body and mind: Extent to which you have problems in the following areas

Severity:	Restriction:
0 No problem means the person has no problem	**0 No restriction** able to participate fully
1 Mild problem (25% of the time)	**1 Mild restriction** (25% of the time)
2 Moderate problem (50% of the time)	**2 Moderate restriction** (50% of the time)
3 Severe problem (more than 50% of the time)	**3 Severe restriction** (more than 50% of the time)
4 Complete problem (more than 95% of the time)	**4 Complete restriction** (more than 95% of the time)

* These questions are based on your normal day to day situations. If you consistently use an assistive device (i.e. hearing aid, contact lenses, and eye glasses) please answer the questions as if you are using the device/s.

Functional problems	Severity	Restriction
Temperament and Personality functions Extent to which your personality or mood affects your day-to-day functioning.	0 1 2 3 4	
Extent to which this problem restricts you to socialize with your family or friends at home or community life		0 1 2 3 4
Focus/attention function Extent to which you can concentrate or shift your focus.	0 1 2 3 4	
Extent to which this problem restricts you to socialize with your family or friends at home or community life		0 1 2 3 4
Memory function Extent to which you can remember things and recall new information.	0 1 2 3 4	
Extent to which this problem restricts you to socialize with your family or friends at home or community life		0 1 2 3 4

Emotional function Extent to which you feel unhappy. Extent to which this problem restricts you to socialize with your family or friends at home or community life	0 1 2 3 4	 0 1 2 3 4
Hearing function Extent to which you can hear normal conversation with several other persons in noise. Extent to which this problem restricts you to socialize with your family or friends at home or community life	0 1 2 3 4	 0 1 2 3 4
Seeing function Extent to which you can see ordinary newsprint. Extent to which you can recognize a friend on the other side of the street Extent to which this problem restricts you to socialize with your family or friends at home or community life	0 1 2 3 4	 0 1 2 3 4 0 1 2 3 4
Sensation associated with hearing and vestibular I Extent to which you have ringing in your ears. Extent to which this problem restricts you to socialize with your family or friends at home or community life	0 1 2 3 4	 0 1 2 3 4
Sensation associated with hearing and vestibular II Extent to which dizziness trigger sensation of falling Extent to which this problem restricts you to socialize with your family or friends at home or community life	 0 1 2 3 4	 0 1 2 3 4

Part 2: Activities limitations and participation restrictions

2.1. If you think about your daily life activities:

➢ Extent to which you have problems in the following areas:

Difficulty:	Participation Restriction:
0 No problem means the person has no problem	**0 No restriction** able to participate fully
1 Mild problem (25% of the time)	**1 Mild restriction** (25% of the time)
2 Moderate problem (50% of the time)	**2 Moderate restriction** (50% of the time)
3 Severe problem (more than 50% of the time)	**3 Severe restriction** (more than 50% of the time)
4 Complete problem (more than 95% of the time)	**4 Complete restriction** (more than 95% of the time)

* These questions are based on your normal day to day situations. If you consistently use an assistive device (i.e. hearing aid, contact lenses, and eye glasses) please answer the questions as if you are using the device/s.

Daily life activates' difficulties	(Activity limitation) Difficulty	Participation restriction
Listening How much difficulty do you have listening to the television, radio, or movies with other family or friends?	0 1 2 3 4	
Extent to which this difficulty restricts you to socialize with your family or friends at home.		0 1 2 3 4
Extent to which this difficulty restricts you to socialize with your family or friends by going to movies, restaurants, or church.		0 1 2 3 4
Communication with-receiving-spoken messages How much difficulty do you have understanding a statement or question?	0 1 2 3 4	
Extent to which this difficulty restricts you to socialize face-to-face with your family or friends at home.		0 1 2 3 4
Extent to which this difficulty restricts your face-to-face social life with family or friends (i.e. Go out to meet your friends or new people).		0 1 2 3 4

Conversation How much difficulty do you have starting, continuing, or ending a conversation, or conversing with several people in a group? Extent to which this difficulty restricts you to socialize face-to-face with your family or friends at home. Extent to which this difficulty restricts your face-to-face social life with family or friends (i.e. Go out to meet your friends or new people).	0 1 2 3 4	 0 1 2 3 4 0 1 2 3 4
Using communication techniques How much difficulty do you have reading lips, or using communication repair strategies (e.g. Ask to repeat, Rephrase,….etc ? Extent to which this difficulty restricts you to socialize face-to-face with your family or friends at home. Extent to which this difficulty restricts your face-to-face social life with family or friends (i.e. Go out to meet your friends or new people).	0 1 2 3 4	 0 1 2 3 4 0 1 2 3 4
Using communication devices How much difficulty do you have with telecommunication, such as calling a friend on the telephone, emailing, texting, or messaging? Extent to which this difficulty restricts you to socialize by phone with family or friends. Extent to which this difficulty restrict you to participate in online support group or online social media.	0 1 2 3 4	 0 1 2 3 4 0 1 2 3 4
Family relationship How much difficulty do you have maintaining your family relationships? Extent to which this difficulty restricts you to socialize with your family or friends. Extent to which this difficulty restricts your social life with family or friends (i.e. Go out to	0 1 2 3 4	 0 1 2 3 4 0 1 2 3 4

meet your friends or new people).		
Handling stress How much difficulty do you have managing and controlling any stressful situations? Extent to which this difficulty restricts you to socialize with your family or friends at home? Extent to which this difficulty restricts your social life with family or friends (i.e. Go out to meet your friends or new people).	0 1 2 3 4	 0 1 2 3 4 0 1 2 3 4
Community life How much difficulty do you have volunteering (helping others) in charitable organizations, service clubs, professional organizations, or social organizations? Extent to which this difficulty restricts your social productivity or belonging?	0 1 2 3 4	0 1 2 3 4
Remunerative employment How much difficulty do you have at your paid work place, if any? Extent to which this difficulty restricts you to socialize with other co-workers at place work or to make social arrangement (i.e. parties)?	0 1 2 3 4	0 1 2 3 4

Part 3: If you think about your environment, where you work and live, indicate to what extent the following factors generally help or hinder your performance in daily life activities and social event participation?

Environmental factors make up the physical, social and attitudinal environment in which people live and conduct their lives. Qualifier in environment:		
Barrier -4 -3 -2 -1	Neutral 0	Facilitator +1 +2 +3 +4

Environmental factors	**Barrier (Hinder)** **Facilitator (Help)**
Products & technology for communication (*hearing aids, cochlear implants, and/or assistive listening devices) 1. Use 2. Clarity of sound 3. Loudness *If you do not use any of the devices mentioned, please answer 0.	-4 -3 -2 -1 0 +1 +2 +3 +4 -4 -3 -2 -1 0 +1 +2 +3 +4 -4 -3 -2 -1 0 +1 +2 +3 +4
Sound 1. Loud sounds (Someone talk loudly; Turn the T.V volume control up). 2. Background noise.	-4 -3 -2 -1 0 +1 +2 +3 +4 -4 -3 -2 -1 0 +1 +2 +3 +4
Support from Immediate family (individuals related to you by birth, marriage or other relationships) including: (Presence, physical-assistance, household-assistance, encouragement and ALL the above listed activities	-4 -3 -2 -1 0 +1 +2 +3 +4
Support from health professionals (Information, Counselling,)Appointment	-4 -3 -2 -1 0 +1 +2 +3 +4
Attitudes of people (friends, Neighbors, Service providers, etc…..) in your society or culture toward your disability	-4 -3 -2 -1 0 +1 +2 +3 +4
Attitudes of immediate family toward your disability	-4 -3 -2 -1 0 +1 +2 +3 +4
Health service system & policies (Preventing and treating your health problems)	-4 -3 -2 -1 0 +1 +2 +3 +4

Brief Test of Attention (BTA)

<u>Part 1: Tell me how many numbers are on each list</u>

A voice on the tape recorder will read a list of letters and numbers. <u>First,</u> you will keep track only of how many numbers you hear. <u>Then,</u> tell me how many numbers were on the list. Please, while the list is being read, make your hands into fists and put them on the table or somewhere I can see them we will being with two examples to make sure you have sure have an idea. Remember, tell me how may numbers.

<u>Part 2: Tell me how many letters on each list</u>

A voice on the tape recorder will read a list of letters and numbers. <u>First,</u> you will keep track only of how many letters you hear. <u>Then,</u> tell me how many letters were on the list. Please, while the list is being read, make your hands into fists and put them on the table or somewhere I can see them we will being with two examples to make sure you have sure have an idea. Remember, tell me how may letters.

This is an example of the score sheet

Item	Correct answer	Response	Item Score
Examples 1. 7 – B – X			
Examples 1. F – 3 – 6			
Trail 1. 5 – K – 7 – H			

Lubben social network scale-Revised

I. **Family:** Considering the people to whom *<u>you are related by birth, marriage, adoption</u>*, etc…

1. How many relatives do you see or hear from at least once a month?

0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

2. Tell me about the relative with whom you have the most contact: How often do you see or hear from the relative with whom you have the most contact?

0 = less than monthly 1 = monthly 2 = few times a month 3 = weekly 4 = few times a week 5 = daily

3. How many relatives do you feel close to? That is how many of them do you feel at ease with can talk about private matters or can call for help?

0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

4. How many relatives do you feel close to such that you could call on them for help?

0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

5. When one of your relatives has an important decision to make, how often do they talk to you about it?

0 = never 1 = seldom 2 = sometimes 3 = often 4 = very often 5 = always

6. How often is one of your relatives available for you to talk to when you have an important decision to make?

0 = never 1 = seldom 2 = sometimes 3 = often 4 = very often 5 = always

II. **Friendships:** Considering all of your <u>friends including those who live in your neighborhood</u>…

7. How many of your friends do you see or hear from at least once a month?

0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

8. How often do you see or hear from the friend with whom you have the most contact?

0 = less than monthly 1 = monthly 2 = few times a month 3 = weekly 4 = few times a week 5 = daily

9. How many friends do you feel at ease with that you can talk about private matters?

0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

10. How many friends do you feel close to such that you could call on them for help?

0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

11. When one of your friends has an important decision to make, how often do they talk to you about it?

0 = never 1 = seldom 2 = sometimes 3 = often 4 = very often 5 = always

12. How often is one of your friends available for you to talk to when you have an important decision to make?

0 = never 1 = seldom 2 = sometimes 3 = often 4 = very often 5 = always

III. **Neighbors:** Considering those people who live in your neighborhood...

13. How many of your neighbors do you see or hear from at least once a month?

0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

14. How often do you see or hear from the neighbor with whom you have the most contact?

0 = less than monthly 1 = monthly 2 = few times a month 3 = weekly 4 = few times a week 5 = daily

15. How many neighbors do you feel at ease with that you can talk about private matters?

0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

16. How many neighbors do you feel close to such that you could call on them for help?

0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

17. When one of your neighbors has an important decision to make, how often do they talk to you about it?

0 = never 1 = seldom 2 = sometimes 3 = often 4 = very often 5 = always

18. How often is one of your neighbors available for you to talk to when you have an important decision to make?

0 = never 1 = seldom 2 = sometimes 3 = often 4 = very often 5 = always

De Jong Gierveld Loneliness Scale

Please indicate for each of the statements, the extent to which they apply to your situation, the way you feel now. Please circle the appropriate answer."

Questions	Yes	More or Less	No
1. There is always someone I can talk to about my day-to-day problems			
2. I miss having a really close friend			
3. I experience a general sense of emptiness			
4. There are plenty of people I can rely on when I have problems			
5. I miss the pleasure of the company of others			
6. I find my circle of friends and acquaintances too limited			
7. There are many people I can trust completely			
8. There are enough people I feel close to			
9. I miss having people around			
10. I often feel rejected			
11. I can call on my friends whenever I need them			

Relationship Assessment Scale

A 7-item scale designed to measure general relationship satisfaction. Respondents answer each item using a 5-point scale ranging from 1 to 5

1. How well does your partner meet your needs?	Poorly 1	 2	Average 3	 4	Extremely well 5
2. In general, how satisfied are you with your relationship?	Unsatisfied 1	 2	Average 3	 4	Extremely satisfy 5
3. How good is your relationship compared to most?	Poor 1	 2	Average 3	 4	Excellent 5
4. How often do you wish you hadn't gotten into this relationship?	Never 1	 2	Average 3	 4	Very often 5
5. To what extent has your relationship met your original expectations?	Hardly at all 1	 2	Average 3	 4	Completely 5
6. How much do you love your partner?	Not much 1	 2	Average 3	 4	Very much 5
7. How many problems are there in your relationship?	Very few 1	 2	Average 3	 4	Very many 5

APPENDIX E
RAW DATA OF THE OBJECTIVE AND SUBJECTIVE OUTCOME MEASURES

ID #	Vision	PTA RT	PTA LT	ANL	BKB-SIN	TFI	DHI	SSQ	BTA	DSB-L	DSB-V	MoCA	DGS	LSNS-12	RAS	LSIS-DJG
1	.8	63.75	62.50	12	2.00	.0	18	3.26	12	5	3	23	14	42	35	5
2	1.0	28.75	32.50	0	-1.50	.0	10	4.81	19	6	5	24	6	35	32	4
3	.6	41.25	52.50	0	.00	5.2	6	6.48	14	6	4	24	0	43	33	4
4	.6	13.75	15.00	0	-1.50	.0	0	7.20	18	4	6	28	4	54	35	2
5	.5	67.50	21.20	2	-2.00	.0	6	8.57	9	8	6	27	0	34	35	0
6	1.0	18.75	16.25	4	-2.25	.0	0	8.04	19	8	9	29	1	41	34	0
7	1.0	45.00	38.75	5	1.00	.8	0	7.24	12	7	7	25	3	44	35	3
8	1.0	15.00	18.75	5	-1.75	.0	0	9.69	14	6	4	24	0	42	33	0
9	1.0	55.00	57.50	7	4.50	20.0	0	5.48	13	7	10	28	5	39	35	3
10	.6	35.00	33.75	4	-1.75	.8	0	8.75	14	12	13	30	0	34	34	4
11	1.0	28.75	27.50	0	-.75	1.6	6	8.24	20	9	6	28	5	26	32	6
12	1.0	73.75	65.00	6	4.50	6.4	50	3.83	7	6	6	21	27	22	31	11
13	1.0	21.25	18.75	2	-.75	.0	16	6.48	15	5	6	23	5	43	31	1

14	1.0	27.50	37.50	8	-.50	.0	0	5.12	13	5	6	22	4	24	31	3
15	.8	42.50	42.50	4	.75	.0	8	7.09	9	7	5	26	4	24	35	9
16	1.0	35.00	30.00	4	-1.00	38.4	26	7.71	15	9	6	29	7	40	34	7
17	1.0	56.25	77.50	2	3.50	.0	8	5.91	5	8	5	27	5	45	33	7
18	1.0	21.25	20.00	0	-2.75	.0	0	8.32	19	6	6	28	0	37	35	0
19	.8	15.00	23.75	2	-1.75	.0	0	9.77	15	6	8	27	0	44	35	0
20	1.0	35.00	30.00	-2	-3.00	.0	32	9.24	19	11	12	30	0	40	35	1
21	1.0	53.75	21.25	6	1.75	.0	10	6.55	16	7	5	27	5	51	33	7
22	.6	28.75	23.75	4	-1.75	18.0	0	8.97	20	6	5	23	6	43	35	2
23	.8	25.00	32.50	4	.50	.0	0	8.16	18	9	8	23	12	31	32	2
24	1.0	28.75	27.50	6	-1.25	.0	0	9.28	19	12	12	30	0	51	32	3
25	1.0	12.50	12.50	4	-.75	.0	0	6.95	17	8	5	27	18	46	34	6
26	1.0	38.75	36.25	8	-.75	11.2	6	7.38	15	6	5	24	2	39	25	2
27	.6	28.75	42.50	4	-.25	.0	0	6.10	20	8	7	29	2	51	32	0
28	1.0	16.25	17.50	1	-1.50	34.0	0	7.20	20	9	6	29	7	44	27	1
29	.5	33.25	22.50	0	-1.25	.0	0	7.67	18	7	7	21	2	41	31	2

30	.5	27.50	30.00	9	-1.75	2.4	0	6.28	14	6	4	28	11	36	35	1
31	1.0	13.75	21.25	10	-.50	14.8	4	7.25	16	6	6	25	13	44	34	1
32	1.0	47.50	56.25	4	1.25	15.2	2	7.02	10	9	8	28	11	33	29	2
33	1.0	15.00	16.25	8	-2.00	.0	10	8.91	20	7	6	29	2	48	25	0
34	1.0	46.25	48.75	10	-1.50	.0	0	8.36	11	7	7	28	4	41	33	2
35	1.0	25.00	22.50	0	.75	.0	14	9.30	19	8	8	27	0	40	35	3
36	1.0	32.50	22.50	6	-.25	1.2	0	8.77	20	8	9	26	3	55	33	0
37	.8	27.50	25.00	8	-1.25	12.0	0	7.16	19	6	4	26	2	44	35	1
38	.6	20.00	12.50	4	-1.75	12.8	0	9.61	19	6	5	29	0	32	35	2
39	1.0	43.75	22.50	8	-1.75	.0	0	6.06	18	6	6	23	4	39	28	5
40	1.0	66.25	16.25	4	2.50	42.4	16	4.39	16	7	6	27	10	32	25	5
41	.8	16.25	23.75	6	.00	1.2	0	7.28	12	5	7	27	1	44	31	0
42	.6	21.25	26.25	10	-1.75	.0	0	8.36	19	11	8	28	1	40	23	0
43	1.0	18.75	18.75	6	-.25	.0	24	8.20	18	8	7	28	17	19	35	11
44	1.0	31.25	26.25	6	.00	.0	6	9.04	16	7	7	27	2	37	27	5
45	1.0	47.50	40.00	2	2.25	.0	26	6.78	17	5	6	25	6	36	24	0

46	.8	41.25	10.00	8	.25	5.6	0	8.01	18	9	11	30	4	42	30	3
47	1.0	30.00	32.50	8	.50	.0	10	6.60	15	9	7	25	3	28	34	2
48	.6	43.75	46.25	4	2.50	.0	0	9.40	18	5	6	22	2	43	35	2
49	1.0	40.00	40.00	10	-1.25	5.2	0	7.40	20	8	5	30	3	42	35	0
50	1.0	18.75	15.00	6	-.75	.0	0	8.47	12	13	10	30	7	36	35	2
51	.8	38.75	45.00	8	2.00	16.0	0	7.12	19	11	11	30	0	38	35	0
52	1.0	35.00	37.50	12	1.25	13.2	0	6.83	18	8	7	30	5	46	33	4
53	1.0	50.00	48.75	4	2.50	28.4	0	8.75	14	10	12	30	5	35	29	7
54	.4	56.25	58.75	2	3.75	27.6	6	4.89	7	10	5	24	13	29	35	9
55	1.0	35.00	32.50	6	.25	.0	6	8.83	17	7	6	27	3	56	35	0
56	1.0	41.25	53.75	10	1.75	.0	0	5.51	11	6	5	24	4	33	31	4
57	.8	40.00	26.25	2	.50	12.8	30	4.46	20	8	8	25	1	37	35	5
58	.6	17.50	27.50	12	.00	6.0	0	9.22	7	7	6	22	13	21	35	9
59	1.0	36.25	40.00	2	-.25	.0	8	8.79	17	11	8	28	6	33	30	3
60	.5	7.50	10.00	-2	-2.50	.0	0	9.49	19	11	8	29	13	42	25	1
61	.8	46.25	41.25	8	-1.25	6.8	16	7.02	19	7	9	28	5	44	33	0

62	1.0	68.75	68.75	8	-.75	53.6	14	7.68	17	8	8	27	20	28	26	6
63	1.0	51.25	52.50	2	5.50	.0	12	5.16	15	7	6	18	3	38	20	4
64	.4	22.50	13.75	0	-.25	.0	14	9.04	18	6	7	30	8	34	35	2
65	1.0	41.25	47.50	10	3.50	.0	0	9.30	4	4	6	21	2	41	35	4
66	.8	15.00	8.75	4	-1.00	.0	0	9.34	18	10	8	27	5	30	22	7
67	.8	36.25	31.25	-2	-1.50	21.2	24	9.55	18	6	7	26	3	54	30	3
68	1.0	26.25	21.25	2	-.75	6.4	16	7.28	13	9	8	29	4	46	35	1
69	.8	18.75	18.75	8	-1.50	.0	0	9.00	17	8	8	27	0	37	35	1
70	1.0	28.75	30.00	0	-.75	.0	20	7.87	18	7	9	23	2	34	21	4
71	.8	33.75	37.50	-2	-.50	3.6	0	8.72	14	6	7	29	0	40	31	1
72	1.0	15.00	15.00	-2	.00	.0	24	7.93	19	14	12	26	3	37	28	6
73	.8	11.25	17.50	4	-1.75	.0	6	8.97	14	6	4	26	7	29	21	5
74	.4	58.75	56.25	2	3.25	.0	12	7.38	8	9	7	28	4	36	34	1
75	1.0	7.50	10.00	2	-.25	.0	0	9.31	19	8	10	26	3	37	21	5
76	1.0	28.75	28.75	4	.00	.0	36	6.97	18	6	6	27	0	50	31	1
77	1.0	28.75	28.75	2	-.75	.0	0	6.81	15	7	7	28	5	37	34	3

78	1.0	12.50	18.75	6	-1.50	9.6	0	8.87	17	9	9	29	3	25	35	3
79	.5	38.75	41.25	12	1.25	.0	0	6.89	10	8	5	26	8	43	27	2
80	.8	7.50	11.25	-2	-1.50	.0	6	9.29	17	5	6	27	0	29	28	5
81	.6	23.75	42.50	0	-2.50	.0	0	7.81	20	9	8	25	3	39	35	0
82	.5	17.50	17.50	0	-1.25	.0	0	8.02	17	8	8	22	2	46	35	1
83	.8	16.25	12.50	-2	-1.50	6.0	0	8.44	19	8	8	26	0	44	35	1
84	.8	15.00	17.50	8	.50	.0	0	9.14	15	5	6	28	1	34	35	3
85	1.0	48.75	47.50	-2	5.75	2.4	4	6.36	6	6	4	24	6	9	30	3
86	.6	13.75	13.75	-2	-1.50	.0	0	6.41	11	5	5	22	0	29	33	2
87	1.0	25.00	30.00	2	-1.25	3.6	0	7.10	19	8	6	30	2	37	30	4
88	1.0	13.75	25.00	0	-1.50	.0	0	8.36	20	9	6	27	2	46	35	0
89	1.0	30.00	17.50	-2	-1.00	.0	0	8.08	16	9	8	30	4	41	33	4
90	.8	31.25	42.50	-2	1.00	42.8	0	7.93	14	6	8	25	19	22	35	8
91	1.0	22.50	20.00	0	-1.00	.0	4	9.04	19	9	6	28	1	47	25	2
92	1.0	47.50	45.00	2	-.75	.0	0	7.22	19	6	4	26	2	42	28	1
93	1.0	68.75	28.75	8	-.25	51.2	30	5.53	20	9	10	27	2	47	22	0

94	1.0	20.00	30.00	2	-.25	.0	4	8.97	16	6	6	23	2	27	35	4
95	1.0	28.75	38.75	12	1.75	27.2	0	5.77	12	4	4	25	10	20	24	6
96	1.0	41.25	31.25	-2	-1.00	7.2	10	6.65	8	6	4	26	3	39	34	5
97	1.0	16.25	5.00	2	-1.25	4.8	12	7.48	19	8	12	29	1	50	35	0
98	1.0	8.75	11.25	-2	-1.50	.0	0	9.24	16	8	8	27	6	36	35	6
99	.8	26.25	22.50	2	-.25	18.0	28	5.00	20	7	6	24	12	14	17	1
100	1.0	27.50	25.00	0	.25	.0	6	7.26	16	8	8	28	5	25	35	1
101	.8	32.50	35.00	2	-1.75	5.2	0	9.08	15	5	6	29	1	40	32	2
102	.5	67.50	17.50	0	-1.50	.0	32	4.12	13	10	6	28	4	31	35	5
103	.8	25.00	62.50	-2	.25	.0	0	8.95	12	6	7	29	0	36	30	2
104	.5	35.00	33.75	0	.50	.0	58	7.63	18	5	5	26	23	47	35	7
105	1.0	47.50	58.75	0	6.50	4.4	4	5.44	9	8	8	28	4	42	26	5
106	.8	18.75	28.75	4	-2.25	.0	0	8.04	18	11	6	25	0	31	35	1
107	.8	42.50	50.00	-2	-.25	51.6	8	7.02	12	8	6	25	2	26	33	2
108	.5	31.25	35.00	4	-.75	12.0	6	6.12	16	10	7	27	10	13	24	8
109	.8	28.75	45.00	-2	-.25	19.2	0	8.37	8	8	6	29	3	34	35	1

110	.8	35.00	37.50	-2	.25	58.8	0	7.24	17	4	3	27	4	34	23	5
111	1.0	10.00	38.75	2	-1.75	.0	20	7.20	20	7	5	30	7	49	35	0
112	.5	17.50	30.00	-2	-1.25	6.8	4	7.40	14	6	6	25	1	35	23	3
113	1.0	17.50	40.00	0	-1.25	.8	20	7.89	19	12	8	28	0	39	33	0
114	.5	27.50	33.75	4	-2.50	15.2	0	7.57	18	9	8	25	1	50	22	0
115	.6	50.00	38.75	0	2.50	.0	0	6.36	19	12	11	28	9	39	34	1
116	1.0	8.75	10.00	12	-1.75	.0	0	8.26	20	7	9	28	12	42	34	7
117	.8	28.75	33.75	6	2.50	17.2	10	6.10	10	11	11	29	5	49	30	2
118	1.0	12.50	12.50	-2	-2.25	.0	0	8.67	19	4	7	25	20	38	35	4
119	1.0	38.75	55.00	-2	1.75	10.0	6	6.79	11	8	6	28	0	42	31	1
120	.6	11.25	8.75	2	-.75	.0	6	7.67	15	6	5	27	3	41	23	9
121	1.0	93.75	88.75	10	17.25	.0	26	4.34	7	9	11	27	4	45	35	1
122	1.0	21.00	30.00	-2	-.25	.0	12	4.39	9	7	6	24	9	28	33	6
123	.6	75.00	76.25	12	23.50	16.8	10	1.14	4	8	8	24	11	37	28	5
124	.8	23.75	18.75	2	-2.25	2.8	8	9.59	19	5	7	24	9	19	20	10
125	.5	32.50	30.00	4	2.75	.0	0	6.12	13	6	7	27	20	33	25	3

126	.5	52.50	53.75	2	4.75	27.6	62	2.93	9	5	8	29	6	26	31	5
127	.8	33.75	38.75	0	.50	.0	8	9.61	12	7	7	30	9	36	24	4
128	.4	47.50	43.75	3	6.00	.0	10	5.43	2	6	4	20	10	30	35	8
129	.8	120.00	81.25	5	21.00	34.8	30	5.03	2	6	6	18	8	32	33	6
130	1.0	22.50	43.75	8	.00	.0	8	6.69	18	9	5	27	1	33	17	10
131	.8	35.00	38.75	2	.50	56.8	14	6.24	18	5	5	27	2	40	19	5

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BIOGRAPHICAL SKETCH

Dr. Al Fakir has more than 15 years of clinical experience in Clinical Otolaryngology and Audiologic Rehabilitation. She received her Ph.D. from the University of Florida in the spring of 2016. Her research is geared toward exploring predictors of hearing disability from two aspects including activity limitation (e.g. listening) and social participation restriction (e.g. social isolation) by using the Intentional Classification of Functioning, Disability, and Health Brief Core Set for Hearing Loss in Elderly. Findings will make a potential contribution in audiologic rehabilitation programs for elderly.

Dr. Al Fakir received two awards for her Outstanding Achievement in Academic, University and Community Service from the International Center UF Alec Courtelis Award in 2014 and the Graduate Students Council Award in 2015. She also, received the Virginia Association of Aging Award for this study in 2016.

Dr. Al Fakir was highly involved in teaching, mentoring, and community education. She developed the Listening and the Social Interaction Program for older adults using the approach of Cognitive Behavioral Therapy. Also, she published three papers in reputable journals and the fourth paper is in progress.