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Review Article

Touch as an Individual Hearing Aid User Characteristic

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Abstract

Background

Despite being a primary sensory modality, touch is largely ignored by audiologist and speech-language pathologists who treat pediatric and elderly patients who have hearing loss. Touch has implication for auditory (re)habilitation, particularly for the acceptance, use and care of hearing aids and other sensory devices. Touch also is a likely contributor to the variability observed in hearing loss presentation and treatment outcomes.

Aims

The aims of this paper are to describe the physical and perceptual characteristics of touch from a lifespan perspective, and discuss how the development and aging of touch might impact hearing aid acceptance, care and use.

Discussion

Touch is part of the somatosensory system and integrates with other sensory and motor mechanisms to protect and sustain life. It also is a sensitive and critical means of interacting with other people and the environment. Touch perception begins early in life and becomes more refined across childhood, and then deteriorates across adulthood. The impact worsens with associated declines in vision, cognition and motor skills. Age-related diseases also interfere with the use of touch and can impact treatment outcomes.

Conclusion

Touch has implications for the auditory (re)habilitation of infants, children and older adults, and should be considered when designing treatment protocols and when selecting hearing aids and other hearing instruments.

Introduction

Hearing loss is highly variable in form and severity, and does not present uniformly across pathologies and populations. Furthermore, its impact on speech perception and communication is highly inconsistent across individuals. This heterogeneity likely is the result of both auditory and non-auditory factors and has implications for intervention. Differences observed across listeners with hearing loss relate to inherent characteristics, as well as specific needs and listening conditions, and suggest that individualized intervention is critical when providing hearing healthcare. Differences in the sense of touch can contribute to the variability observed in people with hearing loss and should be considered during assessment and intervention. The following discusses some of the physical and perceptual characteristics of touch, and how touch develops and then declines with age. In addition, the implications of touch for auditory (re)habilitation will be presented, along with the potential impact on the acceptance, use, and care of hearing aids and other sensory devices.

Touch

Touch Receptors

The skin is the largest and arguably the least understood sensory organ of the body. It is part of the somatosensory system and associated with about 17,000 mechano-receptors in the skin and surrounding tissue. Touch receptors are sensitive to indentation (pressure) and vibration, and in conjunction with their connecting afferent peripheral nerves, provide some temporal information owing to differences in rates of adaptation and other response characteristics. These mechanoreceptors have medium to large cell bodies and their afferent neurons become myelinated with maturation, thereby exhibiting intermediate to rapid conduction velocities

(Abraira & Ginty, 2013). In addition, most have low mechanical thresholds, meaning that they are responsive to very low levels of stimulations.

There are four primary sensory receptors contributing to touch. The tactile corpuscles (Meissner's corpuscles) and the Merkel cells (Merkel disks) are located in the top layers of the skin, and are most common in glabrous (hairless) skin, such as fingertips, palms, eyelids, lips, oral cavity and soles of the feet. The tactile corpuscles are located in the upper dermis encapsulated in a layer of Schwann cells. They respond to skin movement, pressure and changes in texture or vibrations at very low frequencies, e.g., 50 Hz, (Torebjörk & Ochoa, 1980). They adapt rapidly, have small receptive fields with sharply delineated boundaries, and produce transient responses to stimulus onsets and offsets. As a result, they respond best to objects moving across the skin and are very quick to detect minute movements associated with grip control.

The Merkel cells form into clusters located in the basal layer of the epidermis. They also have small distinct receptive fields but are sensitive to sustained indentation. There is some debate about their neural-like functions (Haeberle & Lumpkin, 2008) and recent research suggests that they actively tune the sensory responses of their primary sensory neurons (Haeberle et al., 2004; Maksimovic et al., 2014). This tuning contributes to the exquisite touch, form and spatial resolution of Merkel cells, making them critical in discrimination and identification of shape, curvature and texture (Chalfie, 2009; Johnson & Hsiao, 1992; Lumpkin, Marshall, & Nelson, 2010; Maricich, Morrison, Mathes, & Brewer, 2012). Merkel cells are highly concentrated in the fingertips, lips, and oral cavity (Haeberle & Lumpkin, 2008), but also are found in hairy regions of the skin where they form into clusters around hair follicles and contribute to touch perceived when hair follicles are deflected (Abraira & Ginty, 2013).

More deeply located mechanoreceptors include the bulbous corpuscles (Ruffini endings) and the lamellar corpuscles (Pacinian corpuscles). The bulbous corpuscles are located in the mid-dermis and are sensitive to skin stretch. They are slow adapting receptors, have large poorly-defined receptive fields and are highly integrated with proprioception and contribute to motor control and vestibular stability (Abraira & Ginty, 2013; Toebjork & Ochoa, 1980).

The lamellar corpuscles are located in the deep dermis and at or near joints. They are most prolific in the hands and are extremely sensitive to high-frequency vibration (i.e., 200-300 Hz). They produce both sustained and transient responses across a large receptive field, often encompassing the entire hand. As a result, the lamellar corpuscles are able to resolve the temporal aspects of vibration but lack spatial resolution. It is believed that they mediate the perception of vibration transmitted to the hands during object manipulation (Abraira & Ginty, 2013).

In addition to these four mechanoreceptors in the skin, touch is sensed by hair follicle deflections via a number of different receptors including Merkle cells (Abraira & Ginty, 2013). Unlike the Merkle cells, some of the receptors and afferent neurons associated with hair deflection are small, slow -acting, unmyelinated and respond best to slow stroking of the skin. These particular afferent neurons feed into the limbic system more than the somatosensory system, and are implicated in the emotional and pleasure aspects of touch (Olausson et al., 2002). There also are free nerve endings near the surface of the skin that detect pressure and stretching of the skin. They vary in their response rates and are present in both hairy and glabrous skin. Of importance is that the combinations of receptors and nerve cell types found in touch offer a range of complex input patterns to the central nervous system and allow for easy distinctions between and identification of touch stimuli such as an insect moving on the skin, a warm breeze, a hand stroke, a needle prick, or the pressure of a hearing aid being held by finger tips.

Another important consideration is that other sensory receptors are in or adjacent to the skin, and are part of the somatosensory system and integrate with touch. They include thermoreceptors, which respond to cold and heat; pain receptors (nocireceptors), which respond to noxious mechanical, chemical, heat or cold stimuli; and proprioceptors, which are located in tendons, muscles and joint capsules and detect changes in muscle length and tension. The touch receptors have a particularly strong relationship with proprioception, as well as motor and vestibular functions. Although not in the skin, vision also has a strong cross-modality relationship with touch, which can be seen in tasks involving shape and spatial perception.

Central Nervous System

The afferent neurons enervating the four major types of mechanoreceptors in the glabrous skin tend to take a fairly direct route to the somatosensory cortex. Their signals are transmitted via medium and large myelinated axons to the dorsal root ganglia (or via afferent cranial nerve fibers to the brainstem if emanating from the head). Signals then ascend to the medulla by way of the ipsilateral dorsal columns. Axons from the second-order neurons in the dorsal column nuclei project cross the mid-line to form the medial lemniscus, and then ascend to the pons and mid-brain, and terminate in the ventral posterior lateral nucleus of the thalamus, although some terminate in the reticular system and others in the cerebellum. From the thalamus, third-order neurons send axons to the primary somatosensory cortex in the post-central gyrus (Kandel, Schwartz, & Jessel, 2000). Touch also has less direct, secondary transmission routes emanating from free sensory endings and smaller receptors and unmyelinated afferent fibers, such as those described above that are associated with hair follicle deflection (Abraira & Ginty, 2013).

The cortical areas dedicated to touch include, not only the primary somatosensory cortex, but also the secondary somatosensory cortex, insular (retro and posterior) cortex, and the posterior parietal cortex, which tends to be associated with the initiation of voluntary movement (Lee, 2007). The insular cortex receives projections from the secondary somatosensory cortex and may be important for touch-related learning and memory (Kandel, Schwartz, & Jessel, 2000). Direct input from the thalamus to the dorsal posterior insular cortex is associated with the pleasantness and emotional aspects of interpersonal touch. As suggested previously, it appears to receive touch sensory information from the smaller, unmyelinated fibers serving hair follicles (Björnsdotter, Löken, Olausson, Vallbo, & Wessberg, 2009; Grandi & Gerbella, 2016; Olausson et al., 2002). Readers wanting a more detailed discussion of the receptors and neuroanatomy of touch are referred to a review paper by Abraira and Ginth (2013).

Modes of Touch

Touch traditionally has been divided into tactile and haptic perceptions, with tactile being the passive mode and haptic being the active mode of perception. Tactile perception includes sensitivity to pressure and vibrotactile stimulation as well as spatial acuity. Haptic perception is touch during activity and occurs in coordination with other sensory, motor and cognitive functions. That is, haptic perception includes cognitive involvement and coordination of touch with other sensory (e.g., vision and proprioception) mechanisms and the motor systems to perform intentional tasks such as such as using a fork to eat, place a battery in a hearing aid battery compartment, or placing an earmold in an ear canal (Kappers, 2011; Loomis & Lederman, 1986).

Touch Across the Lifespan

If the sense of touch is intact it can serve as a means of compensating for reduced hearing, but like hearing and vision, it is affected by development and aging. Touch is the first sense to emerge during ontogenesis (Piontelli et al. 1997) and is notable affected in elderly adults. Because touch contributes to our physical and emotional sense of self these changes across the lifespan likely contribute to the variability observed in and across patient groups.

Development

Sensory

Fetuses are constantly touched by their surroundings in utero and by the third trimester are actively touching themselves and their surroundings. By 26-months gestation they show heartrate and movement changes in response to vibration (Kisilevsky, Gilmour, Stutzman, Hains & Brown, 2012; Kisilevsky, Muir, & Low, 1992), and by the third trimester differentially touch themselves and the uterine wall in response to touching of their mother's abdomen (Marx & Nagy, 2017). As such, touch sensory receptors and somatosensory pathways are sufficiently intact at birth to support touch perception. Merkel sensory cells are observable in the epidermis of the palms of the hands and the soles of the feet between 8- and 12-weeks gestation (Bleyenheuft & Thonnard, 2009; Standring, 2005), along with a functioning epidermal neural plexi. Dermal plexi are well established, and tactile and lamellar corpuscles emerge by the fourth gestational month (Bleyenheuft & Thonnard, 2009; Standring, 2005). Some pruning of the Merkel cells begins during the later parts of gestation (Kim & Holbrook, 1995), with the loss of Merkel cells continuing throughout adulthood.

Central nervous system mapping of touch likely has begun by the 23rd week of gestation and has been shown in pre-term infants born as early as 25-weeks gestation (Taylor, Boor, & Ekert, 1996) and is more evident in 7-month-old infants (Saby, Meltzoff, & Marshal, 2015). Like the other sensory mechanisms, development continues through childhood. The cortex thickens, specializes and increases in size until about 4-years of age (Bleyenheuft & Thonnard, 2009), with gyrification continuing through adolescence. (White, Su, Schmidt, Kao & Sapiro (2010). Dendritic connections become more complex, and there is increasing stabilization of synapses. The beginnings of myelination can be observed in utero and proliferate with deposits starting from the periphery and progressing to the cortex. There also is a general pattern of the primary somatosensory cortex becoming myelinated prior to the associative pathways, followed by the long association fibers, which become more operative in the second decade of life (Connolly & Forssberg, 1997). As such, touch becomes more sensitive and sophisticated with development but is not thoroughly integrated with the other sensory modalities until the adolescence (Bleyenheuft, Cols, Arnould, & Thonnard, 2006; Lauronen et al., 2006; Sann & Streri, 2007).

Perception

Research on the development of basic touch perception in infants and children is limited, although it is clear that tactile and haptic stimulation is critical to overall development, not receive frequent and positive touching from their caretakers fail to thrive and are at risk for emotional, cognitive, and various health problems (Feldman, Singer, & Zagoory, 2010; Liu, Liu, & Lin, 2001). For example, postpartum depressed mothers touch their infants less frequently and less affectionately than non-depressed mothers (Ferber, Feldman, & Makhoul, 2008) and this insufficient touching, along with other abnormal maternal behaviors, raises stress levels in infants and can adversely affect infant outcomes (Field, 2011). With the risk of depression elevated in mothers of infants with hearing loss, maternal touch and other communication behaviors should be monitored, and potentially treated when providing auditory (re)habilitation services to families.

Much of the research on touch perception in infants is haptic and involves object manipulation and reaching, with much of the early work being cross-modal where vision was not restricted. However, the literature does show that perception of shape and size constancy is present at birth, with neonates being able to store shape and size information into memory. For example, Streri, Lhote, and Dutilleulet (2000) found that newborns are able to detect differences in the contour of two small objects (a cylinder vs. a prism). By 2 months infants are able to discriminate differences in volume and geometric shapes of objects (Streri, 1987; Streri & Molina, 1993). Perceptions of hardness and texture likely emerge early but are clearly evident around 4- to 6-months of age (Bushnell & Boudreau, 1991; Morange-Majoux, 2011). Similarly, discrimination of weight has been documented in 3-month-old infants, but only under conditions of heightened attention (Striano & Bushnell, 2005). It becomes more evident around 9 months, and requires substantive refinement across childhood (Heller & Schiff, 1991). Complex perception of shape based on spatial configuration is not present until 12- to 15-months of age (Bushnell & Weinberger, 1987) and identification of geometric forms tends to be delayed until early childhood around 4 - 4.5 years, (Bushnell & Boudreau, 1991).

As with other sensory skills, there is refinement of touch perception across childhood and into early adulthood. When assessing orientation and spatial acuity, Bleyenheuft et al. (2006) found that children aged 6 - 10 years were less accurate on grating orientation tasks than older children. Similarly, the development of shape and form perception continues throughout much of childhood – maturing around 14 - 15 years. Some skills may have even longer timelines. For example, Stevens and Choo (1996) reported that children aged 8 to 14 years had worse two-point discrimination (gap detection) than young adults, although it should be noted that reliability and validity issues exist with two-point discrimination tasks.

Exploration

A consideration when working with neonates and young infants is that oral exploration is the first manner of haptic exploration, followed by manual exploration (Streri & Féron, 2005). The lips and oral cavity have high concentrations of touch receptors that stimulate orienting, sucking and swallowing behaviors. They also provide infants with feedback to enhance nursing and feeding skills. As such, oral touch is critical to survival and can be a factor when working with infants who not only have hearing loss but also have neurological and structural abnormalities of the head and neck Beyond feeding, oral exploration can further orient infants to caregivers and provide the first access to objects in the environment. Infants can use oral exploration to learn about their hands and develop intentional control over objects brought to the mouth. With the development of manual control the ability to intentionally grab and hold objects further enhances oral exploration of objects. However, this creates safety concerns with infants wearing hearing aids or cochlear implants because there is increased risk of oral exploration of the devices, and potential damage and ingesting of batteries, earmolds and device parts.

Manual exploration by infants and young children also is an important avenue to know and understand their environments. This is especially true for infants with hearing loss, where environments can be constrained for safety reasons. Manual exploration has been observed in infants as young 4-months of age when infants appear to recognize the boundaries and unity of an object (Streri & Spelke, 1988) and likely is tied to the development of object shape and form perceptual development (Jones & Lederman, 2006). As children age and become more skilled with their hands, manual exploration becomes more incorporated into play, which facilitates more thorough and adept manual exploration of objects and the environment.

Aging

With aging, peripheral and central deterioration of touch occurs. There is a loss of neurons in the somatosensory pathways and cortex, and decreased sensory nerve conduction and reduced sensory action potential amplitudes (Downie & Newell, 1961; Rivner, Swift, & Malkin, 2001). Reduced tactile sensitivity likely is due to a progressive loss of skin receptors and axons; as the pool of receptors and axons decrease so does perception (Bolton, Winkelmann, & Dyck, 1966; Schimrigk & Ruttinger, 1980). As a result, older adults tend to be less sensitive than younger adults to mechanical stimulation, such as light touch and vibration, although the sense of light touch usually is more preserved than vibration sense, with loss of vibration sense becoming maximal after age 65 years (Bruce, 1980; Gescheider, Beiles, Checkosky, Bolanowski, & Verrillo, 1994; Gescheider, Bolanowski, Hall, Hoffman, & Verrillo, 1994; Gescheider, Edwards, Lackner, Bolanowski, & Verrillo, 1996; Goble, Collins, & Cholewiak, 1996; Verrillo, Bolanowski, & Gescheider, 2002; Schmidt & Wahren, 1990; Stevens, Cruz, Marks, & Lakato, 1998). As measured with two-point discrimination tasks, spatial acuity of the skin at the fingertips deteriorates with age (Stevens, 1992). Other measures of acuity such as discrimination of tactile grasp, raised letter discrimination, orientation of lines, and length of lines drawn on the skin also deteriorate with age at a rate of about 1% per year between 20 to 80 years (Manning & Tremblay, 2006; Stevens & Patterson, 1995; Stevens & Cruz, 1996). Object recognition is influenced by cognitive function especially on haptic tasks as compared to tactile tasks (Kalisch, Kattenstroth, Kowalewski, Tegenthoff, & Dinse, 2012). The cognitive vulnerability of haptic perception is reasonable because haptic perception occurs with complex tasks requiring integration across other senses and the motor system. As such, there is greater demand on cognitive resources than that found with tactile perception.

Deterioration with age is more pronounced in the distal than proximal portion of the limbs but the relative differences in sensitivity typically are retained (Stevens, Alvarez-Reeves, Dipietro, Mack, & Green, 2003; Stevens & Choo, 1996). For example, the upper parts of the fingers and toes remain more sensitive than the lower part in healthy adults regardless of age. Some of the differences in touch perception might be due to age-related changes in the skin but most appear to be independent of skin condition (Woodward, 1993). For example texture perception can be influenced by hydration, and therefore age-related drying to the skin, but it does not impact vibrotactile perception (Vega-Bermudez & Johnson, 2004).

Pain and Temperature Perception

As mentioned previously, pain receptors and thermoreceptors are in the skin and are related to touch perception. All are impacted by aging. For example, older adults have reduced thermal responsiveness (Dufour & Candas, 2007) and their thresholds for thermal pain and transcutaneous electrical nerve stimulation increase with age (Procacci et al., 1970; Sherman & Robillard, 1964; Tucker, 1989). Furthermore, central nervous system activation in response to pain-causing stimuli is reduced in older adults suggesting central decline along with peripheral decline (Gibson, Gorman, & Helme, 1991; Nusbaum, 1999; Tucker, 1989). As a result, the perception and control of pain and temperature varies across the lifespan and should be considered when working with individual patients.

Motor and Vestibular

Reduced touch perception has functional implications for motor and vestibular performance and other somatosensory activities. For example, it can impair speech articulation making it difficult to determine hearing loss effects on speech production in elderly persons who have acquired a severe or profound hearing loss (Nadler, Harrison, & Stephens, 2002; Rivner, Swift, & Malik, 2001; Wohlert, 1996). Poor oral-touch sensitivity also can interfere with eating and swallowing, and has a direct impact on health status (Chamberlain et al., 2007). Reduced touch acuity in the hands can influence hand function by reducing finger and hand grip, as well as fine manual dexterity and strength (Dannenbaum & Jones, 1993; Ranganathan, Siemionow, Sahgal, & Yue, 2001; Tremblay, Wong, Sanderson, & Cote, 2003). Because manual touch (along with foot and toe pressures) facilitates balance, the reduction in touch perception with aging likely contributes to the balance and mobility issues experienced by seniors and might prevent consistent access to healthcare including hearing healthcare (Corriveau, Hebert, Raiche, Dubois, & Prince, 2004; Lord, Clark, & Webster, 1991; Tanaka et al., 1996; Tremblay, Mireault, Dessureault, Manning, & Sveistrup, 2004). An additional consideration is that arthritis, diabetes, and tremor, which become more common with increasing age, may further compromise the sense of touch, mobility, and dexterity.

Auditory (Re)habilitation

Infants and Children

The role of touch in the (re)habilitation of pediatric populations with hearing loss largely has been limited to providing alternative modalities for speech and language input. Tactile and electro-cutaneous aids were once used to transform acoustic information to vibrations or electrical signals that could be applied to the skin (Carney & Beachler, 1986; Carney et al, 1993). The Todoma Method, where hands were placed on the face and neck of speakers, was used to provide information about the movements, vibration and air-flow associated with speech production to people who were deaf-blind. It was later adapted to treat speech production in deaf speakers (Alcorn, 1932; Vivian, 1966). The Verbotonal Method (developed by Petar Guberina in the 1950s) used vibratory floor panels, benches and wrist-band vibrators to introduce children with hearing loss to the prosodic characteristics of speech while associating the vibratory information to body movements through structured play, role playing, stories and verbal games (Craig, Craig, & Burke, 1973). When children had developed an awareness of the vibratory patterns and the oral and gestural activities that accompanying speech, amplified acoustic signals were introduced through specialized sound amplifiers. All of these methods were useful for some children but were far less effective than hearing aids and cochlear implants (Carney et al., 1993). The lack of effectiveness was due to vibratory perception being limited to frequencies that are lower than most speech signals, thus requiring extreme frequency transposition and loss of fidelity. Additionally, vibratory perception has a slower rise-time and requires more attention to sustain information in working memory than acoustic perception of speech, making touch a poor modality for learning speech and language. However, touch can be used to provide supplementary input during speech therapy and auditory training. Emotional touch also should be incorporated into parent training programs and considered when providing emotional support to parents and children experiencing anxiety and stress.

Most infants and children with hearing loss are fitted with hearing aids, but the study of hearing aid use, manipulation and acceptance by children has been limited. Most of the research has focused on use-time, or how many hours a day infants and children wear their hearing aids. Walker et al. (2013) found that hearing aid use-time averaged 8.2 hours for a group of 272 infants and children as measured with data-logging, and that use-time increased by age, hearing loss severity and maternal education. They also found that parents typically over-estimated the number of hours their children wore their hearing aids. In addition, this study showed a large range of use-time across children with some children experiencing very limited access to amplification. Consistent with this variability is a report by Yoshinaga-Itano (2013) who found that in a group of 747 children with hearing loss, 142 wore their hearing aids less than 6 hours a day per parent report. Given that parents often over-estimate the amount of time their children wear hearing aids, the amounts of use-time for these children likely was substantively lower than 6 hours. Muñoz, Preston, and Hicken (2014) used data-logging and saw similar use-time results for a smaller group of infants and children (n = 24), but also found that some parents were responsive to feedback and instruction.

One obstacle to consistent use of hearing aids, particularly in infants, is the physical rejection of the hearing aid being placed in/on the ear. Some of this objection may be due to touch sensitivity of the pinna and ear canal. Although there is limited information on pinna and ear canal touch sensitivity, infants commonly pull away or fuss when their ears are touched. The aversion to having their ears touched probably is a protective response, but it often needs to be desensitized so that earmold impressions can be made, earmolds can be inserted, and hearing aids are worn consistently. In some cases pediatric patients may have abnormal (hypo or hyper) touch sensitivity that should be addressed though physical and/or occupational therapy.

Another possible contributing factor is self-efficacy. There is evidence that self-efficacy is important for parents of children with hearing loss (Muñoz et al., 2014), but it frequently is an over-looked factor for children. It has not been well studied in children with hearing loss relative to their hearing aids, but there is anecdotal evidence that children who take early responsibility for their hearing aids (e.g., testing and replacing batteries, cleaning, storing in drying kits, placing them on their ears) wear their hearing aids for more hours and more consistently than children whose parents or teachers take sole responsibility for the maintenance of the hearing aids. They also are less likely to wear a hearing aid with a dead battery or wear a non-functioning hearing aid – a problem common to children and older adults.

Given the development of touch and vision perception, as well as fine motor control, it is reasonable to begin hearing aid training in children by 2- to 3-years of age. They may need some assistance and supervision initially but by school-age their hearing aids (or cochlear implants) should be considered their personal property, as are glasses and cell phones. As they get older, children should be trained to take responsibility for program selection, cleaning, and how the hearing aids interface with other devices. Some periodic monitoring might be needed, but by their early teens, most children have the sensory, motor and cognitive skills to care for and use their hearing aids. If children perceive ownership they also will be more inclined to perceive benefit and use their hearing aids consistently and effectively.

Older Adults

Because of reduced touch and fine manual dexterity some elderly adults experience problems manipulating hearing aids and other sensory devices. Reduced vision and cognitive function can further compromise their abilities to manipulate and care for their hearing aids. Inserting and removing earmolds and hearing aids, manipulating controls, using programs effectively, and placing batteries can be problematic and prevent some from using their hearing aids. Poor manual dexterity has been associated with reduced hearing aid outcomes, limited daily use, and lower hearing aid satisfaction (Humes, Wilson & Humes, 2003; Kumar, Hickey & Shaw, 2000; Wilson & Stephens, 2002). Not surprisingly, the ease with which a hearing aid can be manipulated is an important feature for older adults, whereas it is considered relatively unimportant for younger adults (Meister, Lausberg, Kiessling, von Wedel, & Walger, 2002)   These potential problems strongly suggest that the reduced sense of touch experienced by some older adults might require adaptations in device fittings and controls, and additional sessions, training and follow-up. It also might contribute to the variability to which older adults are proficient with their hearing aids (Desjardins & Doherty, 2009).

Some hearing aid companies have been responsive to these needs and have modified the texture, shape, size and orientation of controls so that they provide greater or more discriminable touch sensations and are easier to manipulate. Singh, Pichora-Fuller, Hayes, Schroeder and Carnahan (2012) compared the abilities of young (18-25 years), young-old (60-70 years), and old (71-80 years) adults to push a control button on two different behind-the-ear hearing aids for which the buttons differed by size, shape and orientation. Time pressure was exerted and the buttons were pushed over nine trials. Performance differences were found between the two hearing aids, and the young group was faster than the two older groups, but the two older groups did not differ. Of interest, however, was that the biggest differences between the young and two older groups were achieved during the first few trials, after which the speed of button pushing by the older groups stabilized and was closer to that of the young group. On further analysis, the authors also found that touch perception and manual dexterity moderately predicted performance on one of the hearing aids but only manual dexterity predicted performance for the other.

In a second experiment, Singh et al. (2012) compared speed of button push and volume control adjustment between two groups of old adults that differed by hand health – one group had healthy-aged hands and the other group had mild arthritis. Five different hearing aids (three behind-the-ear and two in-the-ear) and a remote control were used. Unlike the first experiment, time pressure was not applied. Although there was a tendency for the group with arthritis to be slightly slower than the healthy-hand group, the differences were not significant on either task. However, performance and perceived difficulty did differ by hearing instrument. Regression analyses showed that performance was predicted by the participants' spatial-tactile perception skills, manual dexterity, and arthritis severity but the amount of variance accounted for by these factors was quite low. The overall implication of the study was that mild arthritis should not be a contra-indicator for a particular style of hearing aid, although clinicians should consider the ergonomic limitations of individual hearing aid controls and determine whether they are optimal for each individual patient. Although not tested directly, the results also suggested that time pressure should be reduced as much as possible when working with older adults and that older adults might need additional practice and training to become proficient users.

To ensure that older adults care for their hearing aids and use them effectively it is critical that they receive training at fitting and on subsequent visits until it is clear that they have an acceptable level of performance. Through the training process the ergonomic adequacy and appropriateness of fittings can be assessed and changed as needed. Also, to predict those patients who might need more assistance, it is reasonable to screen for touch, vision, cognitive and manual dexterity problems that might hamper the fitting and training process. Some patients might benefit from physical therapy of the hands or occupational therapy to develop useful adaptive procedures. Because vision can assist haptic perception (Eads, Moseley & Hiller, 2015), appropriately fitted corrective lenses or large magnifying glasses may be beneficial for some patients. Older adults with reduced function (touch and otherwise) may need other therapies, as well as assistance from family members or support/nursing staff, but as with children, the goals should remain that the hearing aids be used consistently, effectively, and with independence and self-efficacy supported as much as possible.

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