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Assessing the impact of multisensory attributes of Textile-based Assistive Devices (TADs) on the experiences of end-users

Abstract

Researchers have defined and measured functional attributes of assistive devices, yet there are multiple dimensions of a device worn temporarily or for life that remain unexamined. The purpose of this study was to explore how the sensory attributes of assistive devices impact consumers in order to build a foundation for a holistic approach to product development. Two online surveys targeting wearers of textile-based assistive devices (TADs) (n=29) and caregivers (n=8) were used for data collection. Survey questions related to sensory experiences (visual, tactile, auditory, olfactory) and describe how device usage and purchasing was impacted. Results suggest that multisensory experiences of users and caregivers involve more complexity than functionality alone. Multisensory effects were diverse in both groups. Some expressed a desire for their device to be more visible and expressive, while others chose not to use, expressing fear of judgment based on visibility. Insight into multisensory aesthetics and how design can be used to conceal, reveal, or provide opportunities for self-expression, as well as avoid embarrassment for the wearer, will help designers understand how assistive devices can be improved and developed to meet the needs of individuals with disabilities. Findings suggest that existing measures of success should include questions about sensory attributes.

Keywords: assistive device, disability, multisensory, caregiver, aesthetics

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Abbreviations: ADL, activities of daily living; AD, assistive device; TAD, textile-based assistive device; UCD; user-centered design; PIADS, psychosocial impact of assistive devices scale; QUEST, Quebec user evaluation of satisfaction with assistive technology

Introduction

More than one billion people globally require at least one consumer product to assist with activities of daily living (ADL) and this number is anticipated to double within ten years.[1] ADL are the fundamental skills such as mobility, bathing, and eating that are considered essential for independent self-care and can be used to assess rehabilitation and disability levels.[2] Products used for assistance with ADL include wearable assistive devices (ADs), some of which are fabricated partially or entirely from textiles. Examples of these wearable textile-based assistive devices (TADs) include rehabilitative knee, arm and wrist braces, splints, shoulder slings, and other soft orthotics. While these devices are designed to produce a physiological outcome (e.g. improve body mobility), the full user experience with an assistive device is more complex and multifarious, often including psychological and emotional components. Further to this, many devices are at least partly visible when worn (e.g. not hidden under other items of clothing), thus the wearing of an assistive device may serve as a visual cue, indicating that the wearer's health status has changed, potentially resulting in feelings of isolation and stigmatization in the wearer.[3]

A lack of attention to multisensory elements in the design and development of some categories of textile-based assistive devices (TADs) has resulted in products that compound stigmatization, contributing to negative outcomes such as abandonment or rejection of the device.[4] Multisensory elements can be defined as visual, tactile, auditory, olfactory and gustatory. While vision and touch are the dominant sensory experiences associated with consumer perceptions of products,[5] other sensory inputs, including smell, also play a role.[6] These inputs shape the practical, experiential, and affective aspects surrounding product ownership. When engaging with a product, its sensory properties and functionalities impact the way a user feels, behaves, and appraises the product.[7,8]

To understand the multifaceted TAD user experience, sensory responses associated with usage must be identified and examined. To provide these necessary insights, the current study focused on how multisensory properties of TADs are understood and expressed by users and caregivers. The study also examined the impact that sensory inputs have on utilization effectiveness, social identity, and self-image. Caregivers were included in the data collection process as they are indirect users of TADs, especially if they are involved in the daily use, such as donning and doffing (putting on and taking off) of such devices.

A qualitative approach was adopted for this exploratory study, involving an online survey for data collection. The survey consisted of closed and open-ended questions, designed to establish a baseline understanding of user and caregiver multisensory experiences relating to their engagement with textile-based assistive devices. Findings from this study could provide insight for product designers, developers and healthcare practitioners so that multisensory experiences can be given greater consideration as inputs in the design and development of future TADs. Additional design considerations may allow TADs to move beyond the purely functional and corrective to provide greater emotional and sensory engagement for the user.

Literature review

Assistive devices take many forms and can incorporate multiple technologies. Expectations of such devices include helping, enabling, enhancing and allowing users to perform some type of activity.[9] Success of an AD is measured primarily by its ability to help a user perform a specific function, either through active or passive means.

Research has suggested that consideration of user-based needs, such as aesthetics, self-expression, and functionality, should also be incorporated into the ideation and realization of assistive products, to increase user engagement and experience.[10–13] However, most academic research into the design and development of ADs in general has focused largely on measuring the degree of functional assistance offered, as well as assessing outcome effectiveness.[14–16] Few studies have focused on aesthetic and self-expressive criteria specifically for TADs[17] using a multisensory approach.

Attention to aesthetics, which are often operationalized through multisensory attributes, does have implications for the user and caregiver. The success of an assistive device is often contextual. In a temporary disabling situation, rehabilitation might depend on a person's reintegration into society, return to work and participation in meaningful sociocultural practices. For an individual with a chronic disability, the assistive device becomes a lifelong part of a user's daily external identity kit. In either case, the emotional impact of a TAD that is worn on the body, typically over, under and in conjunction with clothing, can be negative. Product design researcher Elsa Rosenblad-Wallin stated that the symbolic value of clothing, which is found in the impression the wearer gives to others, should offer self-esteem, respectability, group membership, status, and confidence.12 This value should also be offered by TADs, and is of utmost importance to individuals who use assistive devices on a long-term basis, as the external self becomes entwined with their disability. As noted by rehabilitation researcher Brookes (1998),[18] ADs of any type can be a signal that someone is disabled or is different from others. Users of ADs have mentioned that the lack of aesthetic consideration in product design contributes to a "product-for-disabled" label.[4] This can make social inclusion challenging, not only due to physical impairments, but also because individuals with disabilities encounter discrimination based on physical appearance.[19]

Active discrimination based on physical appearance can lead to feelings of stigmatization on the part of the user of an assistive device. As sociologist Grue (2016) said about assistive products, "It is the people who use them – who are seen to use them – that unambiguously appear as disabled in public (p. 961)".[20] When stigmatization leads to avoidance or abandonment of assistive devices, there are detrimental implications for mental and physical health as well as social participation.[21] Goffman (1963) introduced visibility as an important factor in the stigma experience. Having a highly visible stigma, such as a potentially stigmatizing product, causes a person to be discredited.[22] Jones et al.[23] defined stigma as a mark that links a person to undesirable characteristics.[23]

Design strategies based on user input can offer effective solutions for augmenting or deemphasizing features of assistive devices, as well as elevating the aesthetic impact of a device for those who might use it as a means of self-expression. In large part due to disability activism in the last ten years, an increasing number of individuals publicly identify with a disability culture, that is, a culture formed by a shared set of beliefs, values and behaviors around the construct of a disability.[24] This trend is leading to efforts in combating negative narratives surrounding disability by instead celebrating disabled individuals as capable and thriving members of society. The queer-crip movement, for example, has located parallels between the marginalized status of queer and disabled communities, and subverts the idea that disabled people should hide their disabilities.[25]

As assistive devices and technologies are outward facing signifiers of disability, it is no surprise that much of the focus in reshaping cultural constructions surrounding disability have centered on assistive devices. On a commercial level, DIY customizable designs which highlight the device, rather than masking it, are seen in many slings and braces sold online on sites such as Etsy.com. Profita (2017) found that customization of ADs is an important element in granting individuals agency, ownership, and pride in wearing a device commonly associated with marginalization.[26] However, there is limited literature connecting identity construction and disability to guidance in the design and development of enhanced ADs on a larger scale. Identifying these complex social ties could lead to the development of devices that not only support functional independence, but also allow users to maintain and celebrate their culturally defined social roles.

Despite the fact that ADs can reduce environmental barriers and enhance independence, one third of devices are abandoned after three months to five years of use.[21] Given the high rate of abandonment, user experience relating to aesthetic preferences and direct, multisensory engagement with a device should be examined. A greater understanding of preferences as they relate to visual, tactile and auditory experiences specifically, could enable further understanding of why users prefer to conceal or reveal their device, or reject it altogether.

User-centered design approach

The current study was set up to elicit information from users of TADs about their experience. As such it is based on the practice of User Centered Design. The user-centered design (UCD) approach has been advocated and studied for some years in response to a perceived lack of attention on the part of the design community to genuine human needs. Keinonen (2010) explained how UCD is a "need-satisfying orientation" and can move "from a limited usability engineering paradigm towards more socially focused and interventionist user experience."[27] In the context of medical products, it has been found that understanding and responding to user needs during design and development results in products that improve patient safety and device effectiveness, and reduces product recalls and modifications.[28] UCD has also played a role in the process of innovating assistive products. Mallin and Carvalho (2015) found that when UCD is applied, the potential to enhance assistive equipment with stylistic, formal, functional, and emotional qualities is increased, matching the designer's ideas with the real needs of users.[29] Connecting designers with user needs is critical when taking into account that disability is a highly personal and individual experience. As designers themselves may not be directly engaged with the limitation and outcome for which they are developing products, gathering input from those who will engage with the product creates an empathic link to users' emotions.[30] This in turn can inform design choices that will increase the potential of success in the product. This user input, traditionally confined to the purely functional aspects of devices, should be augmented with multisensory user needs and desires.

Multisensory engagement to inform product design and development

When interacting with a product, users gain pleasure or displeasure from senses that are activated. This sensory activation may be in response to the texture of a product, the noises a product makes, how it smells, etc. Sener and Pedgley (2015) argued that in the absence of satisfactory sensory activation, a product may still provide functionality but will offer far less pleasure.[31] Understanding a user's multisensory evaluation is critical as it influences their overall attitude toward the product and purchase intentions.[32] Multi-sensory design therefore seeks to enhance the functionality of products, as well as the desirability to use and interact with a product.[8] When applied to apparel design, consideration must be given to not only the visual appearance

of a garment and the user-clothing-environment interaction, but also in the pleasure perceived through all sensory modalities. Matté et al.[33] referred to this as the "psychological comfort of clothing (p. 55)".[33] This concept logically extends to ADs, as sensory interactions are fundamental in shaping the experience for a user and impacting the longevity of product usage.

Metrics for assessing ADs

Various scales have been developed to predict discontinued use or abandonment of assistive devices to improve understanding of the user experience. The Psychosocial Impact of Assistive Devices Scale (PIADS) was developed to measure the impact of ADs in three areas; functional independence, well-being, and quality of life.[34] This 26-item scale includes questions that examine to what extent the device helps the user, makes them feel empowered, and impacts their self-esteem. The PIADS has been translated into several languages, and it is used in both clinical and research contexts to study the impact of assistive technologies and predict use/abandonment.[35] While the scale has been shown to be reliable, it does not define the specific attributes of a device or technology that either positively or negatively impact the three areas measured. In other words, implementing the scale will only show part of the user experience story. Another tool is the Quebec User Evaluation of Satisfaction with Assistive Technology or QUEST 2.0. This is a 12 item measurement tool to assess user satisfaction with their product specifically in the realms of Device and Services. The Device items measure the physical aspects, including weight, durability, and effectiveness in meeting needs. The Services item relate to maintenance and follow-up. It has been tested in Europe and North America and supported as relevant for measuring user satisfaction.[36] The QUEST 2.0 does include questions about some of the physical features of the device (weight, dimensions, and fastenings), however, like the PIADS, it does not provide data related to multisensory attributes. While the work that went into validating both scales is worth emulating, additional measures are needed to examine how the particular components of a device (color, texture, weight, fit, smell) relate to its psychosocial impact.

Methodology

The objective of this study was to assess whether and to what degree multisensory attributes (visual, tactile, auditory, olfactory) impact user and caregiver experiences with TADs, to provide data useful to future designers of TADs. To achieve this objective, an exploratory research design was selected to gather in-depth preliminary data from a small purposive sample of active users of TADs and caregivers who work with TAD users. Two surveys were created – one directed at users and the other at caregivers – which contained both closed and open-ended questions about experiences with TADs and specifically, how multisensory attributes played into those experiences.

Sample selection and recruitment

After receiving IRB Human Subjects approval, recruiting began among a network of potential participants already known to the researchers. They in turn contacted others in their network, using a chain-referral or snowball sampling technique to recruit more participants for the study. The researchers used their connections with rehabilitation centers, university rehabilitation programs, and sports medicine clinics to promote the study through email and word of mouth. To participate, individuals had to have been wearing TADs for at least a week, or, in the case of caregivers, have worked with someone who had worn TADs for at least a week, and be at least 18 years of age. Caregivers were included in the study because they play an active role in the care process and are able to provide a different perspective on device use and management. The aim was that this sample would present expanded data that goes beyond what users can observe from their subjective point of view, including the impact device use has on physical functioning and psychosocial conditions. The recruitment process resulted in a total sample of N= 67, with N=52 users of ADs and N=15 caregivers.

Survey method

Two surveys were constructed, one for users of TADs and one for the caregivers. TAD users were asked about their own experiences, while caregivers were asked about the experiences of their patients/clients. The two surveys, which were administered and completed online, began with IRB consent protocol, then moved into screening questions, including information about the nature of the user's disability, the length of time that the TAD was used on a daily basis, and for how long the TAD had been in use. Subsequent questions were grouped by topic, including visual appeal, design modifications, the impact of visual appearance on the choice to wear the device, and tactile, auditory and olfactory attributes. Open-ended questions at the end of the survey focused on reasons for modifying, purchasing, or choosing not to wear a device. Finally, demographic questions were included to build a profile of the participant groups and to assist in aggregating categories of data.

Data analysis

The user and caregiver surveys were analyzed separately to determine any differences and/or patterns in the data, and to benchmark initial discovery of information. In both cases, initial information related to demographics, including diagnosis, type of TAD, acquisition, and duration of use were analyzed using descriptive statistics. Data relating to each of the sensory attributes were analyzed using both descriptive measures and thematic identification of open-ended responses. Finally, any data representing similarities and differences between user and caregiver experiences were identified and described.

Results - Users

A majority of the user group were aged between 18-24 and in total, just over 80% were 54 or younger. The user group presented themselves as predominately female, with a majority having an educational level at Bachelor's degree or above (~46%). Racial distribution for the user group skewed in favor of white (62%) with 17% reporting mixed race and 4 people reporting other. There was one Black and one Asian participant. Almost 50% reported incomes of over $75,000 putting the sample above average household income level for the United States, which was $62,521 in 2020.[37]

The majority of diagnoses experienced by the users of TADs (n=29) were ligament injuries and muscle sprain, followed by fractures (Figure 1). Other diagnoses mentioned included stroke; arthritis, Spinal Cord Injury (SCI); ACL; carpal tunnel; hyper mobility; tendonitis; tissue disorders and varicose veins, showing a wide variety of physical impairments in the sample. Users were able to select multiple diagnoses on the survey as applicable to their situation.

Type of TAD and usage breakdown

The majority of assistive devices referred to in the study were used for the upper body, including hand/wrist braces (n=12) and shoulder braces/slings (n=10). Other devices mentioned included ankle/foot orthotics (AFOs) (n=8), knee braces (n=5), compression socks, finger braces and a neck brace (1 each) (Figure 2). Participants

reported obtaining their TAD through a prescription from a health care professional (n=15), as well as over-the-counter (10 online and 9 in store), with a couple of participants stating that their physical therapist "made" their TAD and one who stated that theirs was provided to them directly by their physician.

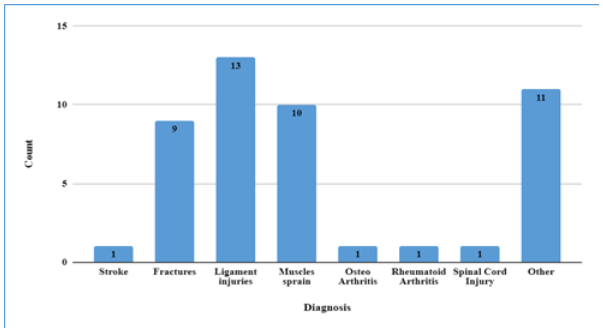

Figure 1 Distribution of disability diagnoses among User group.

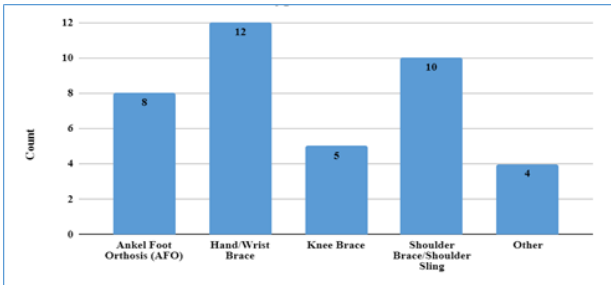

Figure 2 Distribution of types of TADs among User group.

When asked how the TADs assisted their condition, a slight majority of users (59%) stated that they helped with pain. Other benefits listed included increased mobility and stability in joints; decreased joint stiffness, and helping with subluxation (having a spinal vertebra out of position) issues. When asked about negative effects of their TAD, 41% had not experienced any negative effects, but some experienced skin irritation; device slippage; decreased functionality; pain and drawing unwanted attention. Fifty two percent of participants stated that they wear their TAD for a few hours each day (n=15), with about 25% wearing it 24 hours a day. The term of required use was evenly split between a short duration (one week to three months) and indefinite. The majority had been wearing their device for less than three months at the time of the survey, however, 27% had been wearing their device for more than a year.

Sensory attributes

The first sensory aesthetic attribute under investigation related to visibility. One hundred percent of respondents agreed that the device was visible to others when worn, and 64.3% stated that they chose not to wear the device due to its appearance. When asked about their opinions of the visual appeal of their device, 79% of users disagreed with the statement "I find my Assistive Device visually appealing". Sixty two percent were not satisfied with the design options available to them; 75% agreed that color choice influenced their decision when purchasing an assistive device and that fabric surface design (or pattern) influenced their purchase decision. Sixty two percent of respondents indicated that the style of the device influenced their purchase decision (we gave examples of sporty, formal, casual or trendy as stylistic options), while 86% agreed that fit is an important factor in making purchase decisions. Fit was included in the visual appeal category because if a device does not fit the part of the body correctly, it can have an impact on appearance and comfort, and potentially impact the desire of the user to wear the device.

When asked how comfortable they were wearing device in social situations, respondents were fairly evenly split between agreeing and disagreeing. No one was neutral on this topic, suggesting that people have strong perceptions and opinions about it. Respondents were asked to elaborate on the situations where they preferred not to wear the device and written responses included references to both social and functional concerns. Users reported not wanting to wear their devices on formal occasions; occasions when there are "a lot of people around" (larger social situations); occasions when they are with people who know them and situations where they want to "impress/look good." One user remembered not wanting to wear their device "when I was younger and had not accepted disability as much." Social/functional crossover occurred for some users who reported not wearing their device; at work because "people ask what's wrong", "while in the office, when I will be seen on camera" and "when I'm trying to work and it inhibits/limits my ability to function". Some of the responses to this question focused on specific aspects of social activity, such as eating outside the house, because it may become more difficult to hold utensils. One user offered further explanation of their decision:

I have definitely experienced prejudice and discrimination multiple times before, so sometimes I chose not to use the things I need to stop that from happening as much. I experience a lot more micro aggressions in times when I may "appear" more physically disabled.

One of the survey questions related to how users modify or customizing their device. Some respondents mentioned that they had decorated their device. One stated:

I have done this with many devices over the years and it makes a big difference in both my own mental health and also how others interact with me. I decorate my hearing aids most frequently, and second to that I decorate my cane (and past crutches) a lot.

Another respondent mentioned:

When I was wearing my ankle boot for a long time my dad modified it and took out the sock insert and painted the whole book a matte black color because I wanted the look to be fully one color instead of the pops of red that were on it before at the straps/buckles.

It is notable that one user customized their device to draw attention to it, while the other wanted their device to blend in more.

The next set of questions in the survey were directed towards eliciting responses to the tactile quality of TADs. Participants were evenly divided over whether or not their device irritates their skin. However, when asked to respond to the statement: "I like the way my device feels against my skin", 76% of participants either disagreed or remained neutral, 66% participants agreed that the texture of the device influenced their decision to wear it and 75% agreed that texture influenced the length of time that they wore it. It is important to note that the question was not value-driven, that is to say, the texture could have been an encouragement or a deterrent, pleasant or unpleasant. These results indicated that texture does seem to influence wearability of a TAD in some way, and a majority did not like the way the device feels against the skin. It appears that texture influences their decision to wear their TAD and the duration of time that it is worn.

In response to questions about auditory attributes of TADs, he majority of participants agreed that their device makes a noise

when they put it on and take it off, however they reported different experiences with the device in motion. Almost half agreed that the device made a noise when the wearer moved and the other half either disagreed or remained neutral to this statement. The majority of participants indicated that noise does not influence their decision making to wear the device.

The researchers also wanted to understand the influence of olfactory attributes on the wearability of devices. When asked to assess the statement "The smell of my device is acceptable to me", the respondents were evenly split between disagreement, agreement and remaining neutral. Over half agreed that the smell of their device changed as they wear it (no time range stated in the question). The numbers were also evenly split on whether smell affects wearability, with about half agreeing that the smell of their device does impact their decision to wear it, and about half disagreeing. One participant reported: "When it is new, it does not smell pleasantly [sic]."

When asked if they would like to share other information and/or changes that could be made to the look and feel of their device, participants made many suggestions, including: "Less medical please. The ability to change color or have a more neutral color choice would be nice"; and "I would absolutely love to see brighter more interesting colors that fit my personality like maybe purple, blues, greens, oranges, etc." Participants also suggested: "stitched lettering that says 'Don't ask.'"; "More fashionable"; "More similar to a piece of garment rather than a medical device", and "Different colors and slimmer fit."

Results – Caregivers

In total, there were eight usable surveys completed by caregivers. This small respondent rate did not allow generalizable conclusions to be drawn; however, some findings, which relate to the user respondent pool are reported here.

The first set of questions asked respondents about the interaction between the assistive technology and the person/s for whom they have responsibility. The majority of devices were used to help with fractures and ligament injuries, and represented a wide variety of devices, primarily for the upper body. Like the user group, caregivers were permitted to select multiple responses to these questions.

Sensory attributes

Six of the caregivers (86%) stated that the devices were visible when worn and six disagreed to varying extents that the assistive devices were visually appealing, which is in line with user responses. Five disagreed that they were satisfied with the design options available, and six agreed that color influenced their purchasing decisions as a caregiver, a finding that is aligned with the user responses.

When asked to describe the feel of the devices their patients were using, respondents used the following terms: constrictive, hot, bulky, and sweaty. Six out of the seven disagreed that the person they care for likes the way the device feels against their skin, while five agreed that the device irritates the skin of the person they care for. Six people felt the texture or feel of the device influences the decision of their patient to wear it, but only one person said their patient chooses not to wear the device because of its feel. Results for auditory and olfactory attributes were inconclusive, aligning with user findings.

When asked to name the factors influencing purchasing decision of a TAD for the person they take care of, caregivers responded that durability, fit and texture were the most important factors. Fabric and color were listed as factors in purchasing decisions. Qualitative responses included: "protective devices can often cause rashes from rubbing" and "there are a lot of straps that can be noisy when taking the boot on and off." Caregivers primarily made suggestions for functional changes, such as improving ease of washing, donning and doffing, etc, however, one participant suggested:

It would be great if there was a way to transfer artwork to braces or the ability for an individual to customize the outside appearance of something they (or their team) had to wear continuously

This response demonstrates the ability of caregiver to think empathetically regarding sensory concerns as well as purely functional ones.

Discussion

This research study was intended to address the researchers' assumption that multisensory engagement impacts user and caregiver experiences of Textile Based Assistive Devices. The results of the study reveal information about users' and caregivers' sensory experiences and perceptions, and how these might affect the success of a textile-based assistive device (TAD). Only eight caregivers fully responded to the survey, however almost all the findings align with comments made by the users. Further research may locate the unique value caregivers can offer in the development of assistive products. In the context of user-centered design, it is possible that caregivers can provide an empathic link to designers through their firsthand experiences in working closely with users of an assistive device.

The majority of TADs reported by users in the study were designed and prescribed for upper body usage, such as shoulder, arm, wrist and hand) followed by lower body (leg/ankle/foot). The TADs were mostly prescribed to be worn daily for a few hours. Users specified either very long term/unknown duration or short-term duration (less than a month) which suggests that users were looking at a temporary "cure" for a problem, or were faced with long-term usage for chronic conditions and would be wearing TADs as part of their daily wardrobe choice. It is possible that there is a difference in user attitudes between those needing a "temporary fix" versus those incorporating a TAD into their wardrobe in the long-term.

All respondents verified that their TAD is visible to others and over half chose not to wear it due to the appearance, especially in social situations. They expressed a fear of judgment and the reactions of others to disability as reasons for these decisions. This aligns with previous research that has shown ADs are abandoned due to potential stigma and the ways in which an AD can challenge cultural identity. One respondent mentioned the triggering medical look of devices and wrote:

Many people also have medical trauma that can be triggered by the specific look or feel of a device, or just bad memories they don't want to be reminded of.

Morton, Cogan, Kornfalt, Porter and Georgiadis (2020) in a study on how hospital attire impacts patient well-being, found that people living both with a chronic condition and without associated the wearing of hospital clothing with a specific role (being "sick"), relinquishing control to medical staff.[38] For those living with a chronic condition, they also experienced emotional and physical vulnerability when wearing hospital attire. In addition to the findings of Morton et al., other studies have associated the medical "look" with feelings of depersonalization, stigmatization, devitalization, low social status and lack of privacy. As painful memories of medical trauma related to assistive devices were mentioned in the current study, this may merit further research. How can the design of devices address these feelings,

and/or disrupt negative thought patterns? Specifically, what aspects of the device are traumatizing - single features, or the overall medical "look"? For those who are recovering from disabling situations, are there associations and reminders of being disabled and not in control of one's life?

Color, fabric design, style and fit were all important factors for the majority of users. Users wanted customization to fit their own style, and more than half said they were not satisfied with design options. This implies that there is a need for greater design options and improved visual aesthetics. Customization and efforts to embellish/ decorate/ personalize devices was mentioned by two respondents aged under 25 and playful examples were given such as using stickers and patches to embrace youthful tropes.

In instances where users mentioned wanting to visually modify their TADs, the goals ranged from embellishment for self-expression to neutralizing color to avoid highlighting the device. Aesthetic customization is found in other devices, such as hearing aids and cochlear implants, and users share customization tools and techniques in online communities.[39] One user stated:

I think as a trend most people who are chronically ill or use assistive devices long term or everyday tend to want to customize and have ownership/reclaim these devices, while people with more shorter term conditions, or older people tend to not want this. Of course that depends on the person, but from personal experience and community connection I have seen that how you experience disability socially shapes how you want you devices to look.

I think as a trend most people who are chronically ill or use assistive devices long term or everyday tend to want to customize and have ownership/reclaim these devices, while people with more shorter term conditions, or older people tend to not want this. Of course that depends on the person, but from personal experience and community connection I have seen that how you experience disability socially shapes how you want you devices to look.

This finding resonates with research on social connection among teens with disabilities. In a study aimed to understand how disabled teens cope with stigma, it was found that teens felt a greater sense of belonging with others who have a disability and create friendships in the context of the oppression that accompanies being disabled.[40] Just as teens commonly form and express their collective identities and social connections through fashion choices, self-expression could also extend to a wearable device. Given that textile materials can be modified through a range of surface design techniques (painting, printing, dyeing, stitching), further research may locate what additional expressive and customizable features can be integrated into TADs. It is possible that being able to update the appearance of a device as one ages may encourage prolonged use. Further research may examine the myriad ways users express identity, among age groups and socioeconomic backgrounds, and how that connects to preferred features in TADs over time.

There were fewer comments on customization efforts among the older respondents; however, this does not indicate that this age group is more accepting of the appearance of their devices. More than half of the respondents, across all age groups, said they were not satisfied with design options of currently available devices. This implies that there is a need for greater design options and improved aesthetics, beyond customizable features. For instance, understanding what is causing a "bulky look" (internal boning, thick materials, or Velcro® and other closures) would be useful in developing devices that aesthetically appeal to a broader range of users.

It was also reported that some TADs make sound, primarily when donning/doffing. It would be worthwhile to explore what features of the device generate sound, especially in use, since this can cause unwanted attention. In addition, unpleasant smells were mentioned. It would be meaningful to investigate the materials and finishing treatments that cause this and how unpleasant smells can be minimized. It cannot be determined whether olfactory attributes affect wearability, however, it can be acknowledged that consumers are aware of smells in their TADs.[6] Auditory attributes figured more prominently in the donning and doffing of devices than in the wearing, however, in general, results on sound and smell were inconclusive for both participant groups.

Conclusion and recommendations

Many people need assistive devices, both temporary and permanent, and this is likely to increase as the global population ages. Many of these devices incorporate textiles. The design and production of TADs focuses primarily on functional aspects because many are FDA approved medical devices and are prescribed by medical professionals to facilitate treatment and recovery. However, the user and caregiver experience with these devices may be more complex and deserves further investigation.

Defining the role multisensory aesthetics play in user preferences can lead to positive outcomes in an area that has long received negative user feedback. Users have mentioned the lack of aesthetics in products contributes to a "product for-disabled" label.[4] When this stigmatization leads to avoidance or abandonment of assistive devices, there are detrimental implications for social participation, as well as mental and physical health.[21]

Insight into aesthetics and how design can be used to conceal, reveal, or provide opportunities for self-expression, as well as avoid embarrassment for the wearer, will help designers understand how assistive devices can be improved and developed to meet the needs of individuals with disabilities. Ultimately the aim is to contribute to the development of assistive devices that restore and support function without hindering social participation.

Further investigation should include the recruitment of medical professionals, designers and manufacturers to understand other aspects of the phenomenon. It is also important to widen the number of user and caregiver participants to begin segmenting groups of users with similar devices and/or similar needs. Subcultures defined and brought together by disabilities are also worth investigating in the context of TADs, and their inter- and intra-group communication could provide valuable insights. This survey provided valuable insight into the personal experiences of users through open-ended questions. Further use of qualitative methods should be expanded to include in-depth interviews and focus groups. Data from such studies could be used to inform supplemental questions for existing measures such as the PIADS or the QUEST 2.0 to enable quantitative analysis of more focused sub-categories of assistive devices (such as TADs) as well as sensory and aesthetic attributes.

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Conflicts of interest

Authors declare that there is no conflict of interest.

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