Stigma Threat in Design for Older Adults: *Exploring Design Factors that Induce Stigma Perception*

Chen Li [1,*], Chang-Franw Lee [2], and Song Xu [1]

[1] *School of Design and Art, Beijing Institute of Technology, Zhuhai, China*
[2] *Graduate School of Design, National Yunlin University of Science and Technology, Yunlin, Taiwan*

Health monitoring wearables (HMWs) are an emerging technology to assist healthy aging in older adults. However, stigma perception among elderly users can lead to issues such as non-acceptance or abandonment of HMWs. Based on concepts from social psychology and design theory, this paper deconstructs stigma perception in older adults' daily life from the perspective of identity threat. Using HMW sample cards and real products as stimulus materials, the researchers employed a sentence completion task and a cultural probe to acquire stigma-related collective representations, situational cues, user characteristics, and design factors. Analysis using grounded theory revealed differences in the frequencies with which different HMWs induced stigma perception. The design factors that have the potential to induce stigma are summarized as lack of aesthetic appeal, accentuated social signifiers, poor affordance, and neglect of privacy. These four factors need to be treated with caution in the design process.

Keywords **–** Stigma Perception, Identity Threat, Design for Older Adults, Design Factors, Health Monitoring Wearables.

Relevance to Design Practice **–** By deconstructing stigma perception, designers can learn how older adults interpret health monitoring wearables and attach multiple meanings to them. The findings on design factors related to stigma may help designers to enhance the accessibility and attractiveness of wearable gerontechnology.

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Introduction

The design of *health monitoring wearables* (HMWs) has been a hot topic over the last two decades. Ideally, HMWs can provide older adults with meaningful health data, forecast and avert potential hazards in their lives, and give them independence and safety (Fang & Chang, 2016; Kang et al., 2010). In reality, however, it is not easy to persuade older adults to proactively accept HMWs, as designers need to overcome older adults' *stigma perception* (Rashidi & Mihailidis, 2013; Yusif, Soar, & Hafeez-Baig, 2016). Some studies have found that stigma perception causes older adults to form negative images of end-users, believing that end-users are very elderly people with serious cognitive or physical impairments, or even lonely and socially isolated groups. For instance, Holzinger et al. (2010) found that older adults were willing to buy a wrist-worn vital signs monitor for others but not to use one themselves, because they thought of end-users as elderly people with heart problems; while Pritchard and Brittain (2015) found that although their alarm pendant was convenient and efficacious and reduced the cost of care, older adults felt that using it would cause them to be discriminated against, and so resisted such technology. In a recent research project, we also found that older adults will give up on HMWs because they feel their status is degraded when using such devices. These findings suggest there is a lack of awareness of stigma perception in the domain knowledge of HMW designers. Researchers have long been in the habit of focusing on digital divides affecting older adults in technological practice (Czaja & Sharit, 2013), but the problem of *stigma* is of a different nature. Embedded in the context of the personal and social lives of older adults, stigma perception induces their conjecture about the identity of end-users. Stigma perception is a poorly understood aspect of the *gerontechnology* design space; it involves older adults' negative emotions, the symbolic meaning of HMWs, and social difficulty in older adults towards accepting technology (Page, 2015; Tamrat et al., 2012). Clarifying the roots of such problems may help designers to a new understanding of the relationship between HMWs and older adults. To date, few researchers have conducted detailed, in-depth discussion of HMW-related stigma and thus the issue is worthy of further exploration.

Universal Design and Inclusive Design are likely to offer design approaches and guidelines that would reduce stigma perception, for example by calling for the promotion of fairness by designing products to be accessible to all users, and for the application of mainstream design values. However, designers still misunderstand the mechanisms and causes of stigma in human–computer interaction, and, especially when designing

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Corresponding Author: fionalee1125@qq.com

digital products for older adults, fail to apply suitable methods to prevent the occurrence of stigma issues. In this study, we propose two questions regarding this confused situation in current research: firstly, are there differences in the frequency with which different HMW samples induce stigma perception? In some stigma-related studies, stigma is associated with test samples that are still at the stage of prototype testing (Holzinger et al., 2010; Wu, Choi, & Ghovanloo, 2015), which is likely to create the illusion that stigma arises only in special cases. In the absence of case comparisons, it is difficult for researchers to detect differences in degree of stigma perception. Secondly, are there specific design factors that induce stigma perception among older adults? Many researchers have described the importance of considering stigma in design for disabled or younger people (Farrington, 2016; Jacobson, 2014; Redmond et al., 2014), but to date none has clearly identified which design factors are most likely to induce stigma perception in older adults. As a result, it is hard to collect essential information about stigma perception arising from gerontechnology. Based on these questions, this study analyzes well-developed HMW cases in the Chinese market in order to deconstruct stigma perception among older adults and identify stigma-inducing design factors.

Deconstructing Stigma Perception from the Perspective of Identity Threat

We looked for methods to deconstruct stigma perception among older adults in the literature on social psychology. When exploring the historical context of stigma, Goffman (1963/2009) defined stigma as "an attribute that is deeply discrediting" (p. 3), and found important links between stigma and the stigmatized person's *social identity*. He considered stigma as a special discrepancy between virtual social identity and actual social identity. Later, Link and Phelan (2001), building on Goffman's findings, further clarified the composition of the concept of stigma, defining it as the co-occurrence of labeling, stereotyping, separation, status loss, and discrimination. In this study, we find that as a keyword in the perception of stigma, social identity is also of great significance in design research. Starting from *design semiotics* and *product semantics*, researchers in related fields of study have concluded that what people wear, consume, or use can define their social identities and differences. As a result, some products, such as Rolex watches and the Apple Watch, are considered to be symbols of the user's identity and status (Csikszentmihalyi & Rochberghalton, 2002; Krippendorff, 2006). The Stigma-induced Identity Threat Model (SITM) formulated by Major and O'Brien (2005) can also provide a valuable analytical perspective for design-induced stigma. In this recursive model, stigma perception is interpreted as the stigmatized person's evaluation of *identity threat*, which originates from three factors: *collective representations*, *situational cues*, and *personal characteristics*. The model helps to explain how stigmatized persons respond to social stigma and to elucidate the possible impacts stigma has on their identities. Based on this model, Vaes (2014) developed the Stigma Product Evaluation Model, which focuses on value and arousal during an appraisal process that reveals appraisals from users, bystanders, and society/culture. Such a model can provide designers with clues to detect the existence of stigma.

Building on previous research, in this study we hope to further explore the design factors that provoke stigma perception in older adults by understanding the projection process between HMWs and older adults' social identity. We assume that stigma arises from inadequate communication between the designer and end-users (older adults) in the design process. When designers have a poor understanding of the sense of identity, technology acceptance, and real-life context of elderly users, designers are likely to oversimplify the multilayered needs of older adults towards wearable technology, and this may lead designers to inappropriately apply to the product some design features that may generate stigma, and thereby induce identity threat in older adults during product use. Like other design researchers, we refer to the SITM (Major & O'Brien, 2005). We integrate the concepts and research objects of this model with our research context to create a new research model. In this paper, we first identify examples of stigma-inducing HMW design based on older adults' projection of end-user identity threat onto HMWs. Then, by examining the situational cues and collective representations associated with the stigma arising from these design examples, we seek to distill the design factors behind older adults' stigma perception. Our new model includes four core constructs (Figure 1):

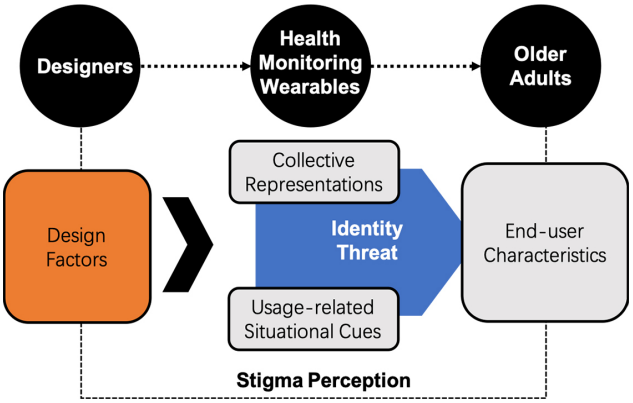

Figure 1. Research model for deconstructing stigma perception. Modified from Major and O'Brien's (2005) stigma-induced identity threat model.

End-user characteristics: Older adults' imagination of end-users directly influences their appraisals of identity threat, and activates projection. Fiske, Cuddy and Peter (2007) used the

Chen Li is a lecturer at Beijing Institute of Technology, Zhuhai. She completed her BSc and MA degrees in Industrial Design at the Beijing Institute of Technology. She received her PhD degree from National Yunlin University of Science and Technology. Her areas of specialty are gerontechnology design, wearable technology, parametric design, and design education.

Chang-Franw Lee is a professor in the Graduate School of Design, National Yunlin University of Science and Technology (YunTech), Taiwan. Currently, he is Dean of the Office of Academic Affairs, YunTech. His areas of specialty are cognitive psychology, ergonomic design, user interface design, universal design, and design education.

Song Xu is a lecturer at Beijing Institute of Technology, Zhuhai. He is also a doctoral candidate at National Yunlin University of Science and Technology. His areas of specialty are interaction design, interaction technology, and design education.

two dimensions of competence and warmth to describe social stereotypes regarding specific groups of people. Their results showed that older adults were rated high on warmth but low on competence, which meant that they were dependent and non-competitive. In this study, we attempt to characterize the social identity of end-users according to different dimensions, in order to find identity characteristics to which older adults are sensitive.

Collective representations: This refers to society at large's shared cultural understandings and stereotypes of older adults. Collective representations affect older adults' lifestyles, beliefs about aging, daily dress habits, and so on. The significance and value of HMWs to older adults and social culture are all part of the content of collective representations, which is what Steele (1997) calls "a threat in the air" (p. 614). People's perspectives on aging within their social lives are continually changing. In ancient Chinese culture, old people were regarded as symbols of wisdom. For example, famous historical figures such as Jiang Ziya and Confucius are well known for their rich knowledge and intellectual accomplishments. In recent years, however, with a rapidly aging population and a rising dependency ratio, the burden of supporting a family has become increasingly onerous, and some older adults are considered as burdens on their families. People are also growing more fearful of getting old. In addition, frequent negative news stories about elderly people, concerning dementia, noisy behavior in public places, ignoring road safety, and so on, reinforce the negative image of older adults in society. These changes in collective representations tend to enhance the stigma perception of older adults. In this study, we elicit stigma-related collective representations from social interactions of older adults that are impacted by their wearing HMWs, in order to delineate the relationship between HMW stigma and the everyday living culture of older adults.

Usage-related situational cues: The usage situation of devices is an important consideration in gerontechnology (Chen & Chan, 2013). Drawing on life experience, older adults are able to judge whether HMWs are suitable or unsuitable for use in different settings. For example, does wearing a product in certain public places attract excessive attention? Will friends look down on me for wearing this product when we get together? Does using the product affect others or make them unfriendly towards me? Influenced by collective representations, older adults often unconsciously make such situational considerations when using HMWs. They can take cues from other people's attitudes to infer whether they would encounter identity threat in certain situations. In this study, we aim to uncover the situational cues that are present when older adults' stigma perception is induced.

Design factors: Design factors are the design methods and elements applied by a designer in configuring a product. They can have both positive and negative impacts on product users. With reference to the issue of stigma, in this study we focus on design factors that are inappropriately employed by designers and have a negative impact on older adults. Each design factor comprises a shared set of inappropriate design features, such as features that cause poor appearance or awkward use, etc. Design factors can reveal the sources of stigma issues in the design process of HMWs. In the process of deconstructing stigma perception, we will categorize the similar design features that are misused by designers, and extract a few easily understandable design factors that induce older adults' stigma perception, so as to assist designers in eliminating sources of stigma in the design process.

Methods

Data Collection Techniques

In order to clarify the differences in the frequency of HMW-induced stigma perception and to identify related design factors, we deconstruct the process by which stigma perception is induced based on the theoretical framework provided by our research model. Sentence completion and cultural probes were used for qualitative data collection.

For the purpose of deconstructing stigma perception in order to identify related design factors, in the first stage of data collection sentence completion was used to find out what types of HMW induced the greatest stigma. Sentence completion entails the researchers providing sentence stems (incomplete sentences) for the users to complete in meaningful ways; this is a projective technique widely applied in consumer surveys and in studies of the symbolic meaning of products (Golde & Kogan, 1959; Kujala & Nurkka, 2012). The advantage of this method lies in rapidly assessing complex constructs and filtering out non-relevant information. Compared with conventional questionnaire surveys, sentence completion is more able to provide valid and flexible answers. In this research we employed a sentence-completion-based questionnaire that was divided into three parts: demographic information, stigma perception in previous experiences, and stigma perception in reaction to HMW samples. In the data collection process, older adults first filled out demographic information; then those who had experience of using HMWs were invited to briefly describe their previous stigma experiences. Finally, the researchers showed the older adults stimulus materials, allowing them to select those that induced the greatest stigma; the older adults then completed the sentence stems by filling in the blanks. The researchers encouraged the older adults to disregard the stylistic qualities of the sentences and to try their best to write and dictate all important information. The design of the sentence stems corresponded to the three constructs in the proposed new model and the older adults' ideal social identity. The sentence stems comprised the nine partial sentences in Table 1.

In the second stage of data collection, we focused on how stigma was induced by a specific HMW sample with the help of a cultural probe toolkit, so as to collect older adults' real user experiences. The selected participants were required to wear real HMW samples chosen by the researchers in their daily lives. The participants had to wear each device for at least two days. During this time, the participants were required to record their experiences related to stigma. As a novel exploratory tool, the cultural probe has been used in previous studies to capture the living culture, beliefs, and social preferences of older adults in the community. The tool stimulates the interest and reflection of older adults on

Table 1. Sentence stems related to stigma perception.

Phase	No.	Sentence Stems
Collective Representations	01	This sample is the most stigma-inducing because _____.
	02	This sample looks _____.
	03	To me, wearing this sample means _____.
	04	This sample reminds me of _____.
Usage-related Situational Cues	05	Compared to other samples, this sample is less suitable for the following situations _____.
	06	If I wear this sample, other people will think I _____.
End-user Characteristics	07	If I wear this sample, I will think I _____.
	08	The typical owner of this sample is _____.
Ideal Social Identity	09	You hope HMWs can make you become a _____ person.

stigma issues, to allow researchers to more carefully explore the culture of older adults' daily lives. In this study, the cultural probe enabled the researchers to discover the interactions between HMWs and older adults, and to understand the impact of HMWs on their social lives. The cultural probe package used at this stage included samples of the four HMWs identified in the first data collection stage as inducing the highest stigma perception, as well as a smartphone loaded with apps related to the four selected HMWs, a digital voice recorder, postcards, pens, mood stickers, and a daily life diary (Figure 2). Before the cultural probe was implemented, each participant was taught in advance how to operate the four samples, to ensure that they could use the samples independently. During the implementation process, we did not interrupt the participants halfway; we collected the cultural probe packages separately after each person had completed the task.

Participants

China defines older adults as those over 60 years of age. Firstly, we recruited a large number of urban residents over 60 years old to fill out the sentence completion questionnaire, through snowball sampling with the help of interpersonal relationships and social networks. A total of 100 questionnaires were distributed, and 73 valid responses were finally obtained, based on content integrity and rationality. The participants were all from provinces and municipalities in northern China, including Liaoning, Hebei, Beijing, Tianjin, Shandong, Heilongjiang, and Jilin, and had been living in their respective locations for more than 10 years. Among them, men accounted for 56.2% and women for 43.8%; 64.4% were aged between 60 and 69, 20.5% between 70 and 79, and 15.1% over 80; 63% had a technical school or high school education; 67.2% had a monthly income of RMB3000 or above; 63% lived with their families, and 34.2% lived alone. Forty-six participants had used a health monitoring smartwatch, and of these, 38 described a personal stigma experience. Twenty-five participants had heard of HMWs but not used them, and two had not heard of HMWs.

For the cultural probe, we reduced the number of participants due to the complexity of the implementation process. In accordance with the older adults' willingness to participate and their time availability, as well as for convenience of distributing and collecting the cultural probe packages, 10 older adults were selected from among the 73 valid questionnaire responses for the cultural probe exploration, all with geographical locations within Liaoning province, China. The ratio of male to female

Figure 2. Tools in the cultural probe package.

participants was 1:1, and the age range was 66 to 79 years. Two of the participants were in good health, while eight suffered from chronic cardiovascular and cerebrovascular diseases. In addition, two of them had low mobility, and one had mild dementia. We visited the older adults before the cultural probe to make sure they were capable of completing the tasks. We learned from the family visits that the older adult with mild Alzheimer's dementia was in the habit of keeping a daily journal to keep from forgetting. This behavior is very similar to the daily life diary tasks in the cultural probe, so we were pleased to incorporate this older adult into our experiments to collect information on the stigma issues that older adults with mild dementia may experience.

Stimulus Materials

In view of the product development level and diversity needed for the stimulus materials, for this study we chose health monitoring smartwatches as the sample HMWs. This is because smartwatches are the most developed in terms of health monitoring for older adults and have a rich variety of functions in comparison with smart eyeglasses, smart clothing and the like, and they already have an elderly user group. Moreover, wristwatches have had different connotations at different stages of the evolution of material life for Chinese older adults, and cultural changes could bring more abundant data to the research.

Sample cards and real smartwatches were used at different stages of the study to awaken older adults' stigma perceptions. For the sentence completion task at the first stage of data collection, we made 20 colored sample cards with pictures of smartwatches and brief introductions of their functions. We found the 20 samples on the online shopping platform Taobao (www.taobao.com) using the search terms "health", "smartwatch", and "older adults" (all three terms translated from Chinese). The samples were numbered from S01 to S20 (see Appendix), and were presented to each participant in the same order during the survey, as stimulus materials. For the second stage of data collection, we selected the four samples (S01, S06, S11, S12) with the highest levels of stigma perception as the stimulus samples for the cultural probe (Figure 3), to help the participants construct their real experiences in daily life. These real products enabled older adults who lacked experience of using HMWs to explore and record their stigma perceptions.

Data Analysis Techniques and Reliability of Coding

At the data analysis stage, we adopted grounded theory to analyze the information from individual participants, and organized the data qualitatively in line with triangulation and coding structure principles, forming a coding system including open coding, axial coding, and selective coding (Corbin & Strauss, 2008). Texts and voice recordings from individual participants were converted into electronic documents and imported into MAXQDA 12 Plus software to assist in the analysis. During the data analysis process, we also made use of the software to convert some qualitative codes into quantized data to conduct simple quantitative statistics. Percentage agreement was adopted as the measure for reliability of coding, applying the formula: Percentage Agreement = Matches / (Matches + Non-Matches). In this study, intracoder reliability was 90%, and intercoder reliability was 70% (the coders were one researcher and two user analysts working on scientific and technological development). The common codebook included open codes and axial codes related to collective representations, usage-related situational cues, end-user characteristics, and design factors, as set out in our research model.

Results

Differences in Frequency of Stigma Perception among Stimulus Materials

In the first stage of data collection, each participant was asked to choose one sample that would induce the greatest stigma perception. The researchers quantified the number of times each of the stimulus materials was selected, so as to uncover the differences between the samples in inducing stigma perception. Figure 4 shows that stigma perception was induced by a large proportion of the samples of smartwatches that have been sold on the market, a fact that deserves attention from designers. The frequency with which stigma perception was induced varied greatly among the different samples. The four samples that were selected the most frequently were sample S01, which was selected by 10 participants, and samples S06, S11, and S12, selected by eight participants each.

Figure 3. Stimulus materials: (left) S11 sample card for sentence completion, and (right) real smartwatches for cultural probe.

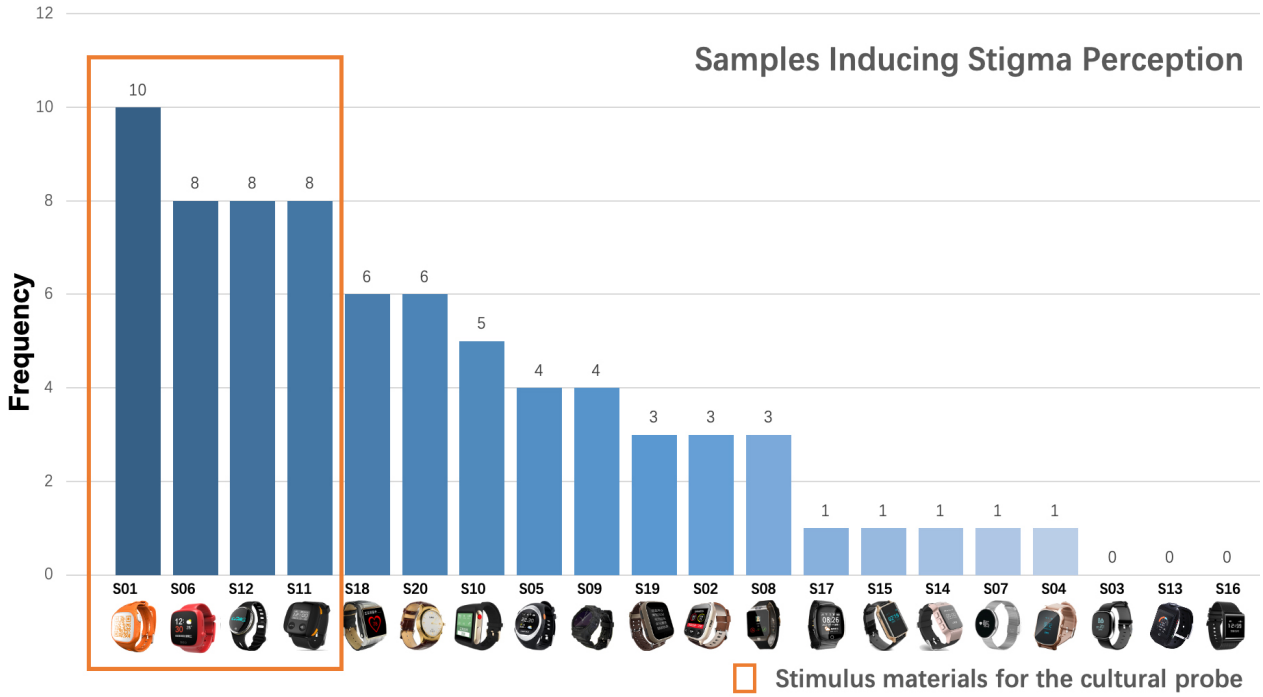

Figure 4. Stigma perception among stimulus materials.

We used the four most frequently selected smartwatches (S01, S06, S11, S12) as the stimulus materials for the cultural probe, so that the participants could experience how the real products affected their daily lives. After many days of experience and exploration, the participants recorded a wealth of information related to their stigma perception as feedback from the cultural probe (Figure 5). For example, some of the older adults took pictures of their own watches for us, describing them as precious accessories, and commenting that compared to the smartwatches for test, their own watches were more elegant and higher-grade in appearance. Some noted that there was a great difference between these smartwatches and their friends' Apple Watches, and stated that the test watches were not good-looking and were of poor quality. Some testified that when they were wearing the samples, the test smartwatches often drew the attention and comments of friends and relatives, who gained the mistaken impression that the participants were sick. Some even thought that the smartwatches were not suitable for their use, and reported wanting to take them off when they went out. These and similar descriptions not only reflect the personal dressing preferences of the older adults and the identity threat posed by the samples, but also reflect the stereotypical attitudes of bystanders and the social culture towards the stimulus materials, providing valuable information for our research.

Figure 5. Some photos, postcards, and diaries collected by the cultural probe.

Design Factors that Induce Stigma Perception

In this study, grounded theory was used to analyze the descriptions in the sentence completion task performed by the individual participants, as well as the data, including pictures and diaries, from the cultural probe feedback. By comparison with existing design theories, the useful data were marked and classified step by step according to the construct in our research model. Then, the coding system was used to make an in-depth analysis of end-user characteristics, collective representations and usage-related situational cues, so as to explore the design factors that induce stigma. Finally, 192 open codes related to design factors were marked and grouped into four axial codes that explain the causes of stigma perception from four perspectives: *lack of aesthetic appeal*, *accentuated social signifiers*, *poor affordance* and *neglect of privacy*. These design factors are explained in conjunction with the context of the original text and coding.

Lack of Aesthetic Appeal

Aesthetic appeal is an important issue in design, and a physical aesthetic experience brought about by a good-looking wearable is an important part of its design (Lin, Chien, & Kerh, 2016), while stigma perception induced by poor aesthetic appeal is the most common design issue raised in the relevant literature (Jacobson, 2014; Vaes, 2014). In this study, we found that stigma perception induced by lack of aesthetic appeal (n = 51) arose from three design features (Figure 6 and Table 2): *conflicting color matching* (n = 18), *inferior material quality* (n = 20), and *unusual shape* (n = 27). For example, in terms of color matching, smartwatch S10's vivid and conflicting color matching of gold and red was felt by older adults to be gaudy and vulgar, and lacking in aesthetic appeal. In terms of material quality, the plastic and silicone texture of smartwatch S06 made older adults consider the device to be a cheap gadget for younger people. Finally, in terms of shape and structure, some unusual shapes, such as S06's regular, thick square design and the massive metal structure around S18's face, seemed strange or unfashionable in the eyes of the older adults. From these results, it can be inferred that older adults have some specific habitual aesthetic standards, and poor aesthetic design may cause older adults to associate a wearable with specific negative categorizations and feel that it projects undesirable characteristics of the wearer, such that they would wish to use the device only in limited situations, or may give it up entirely.

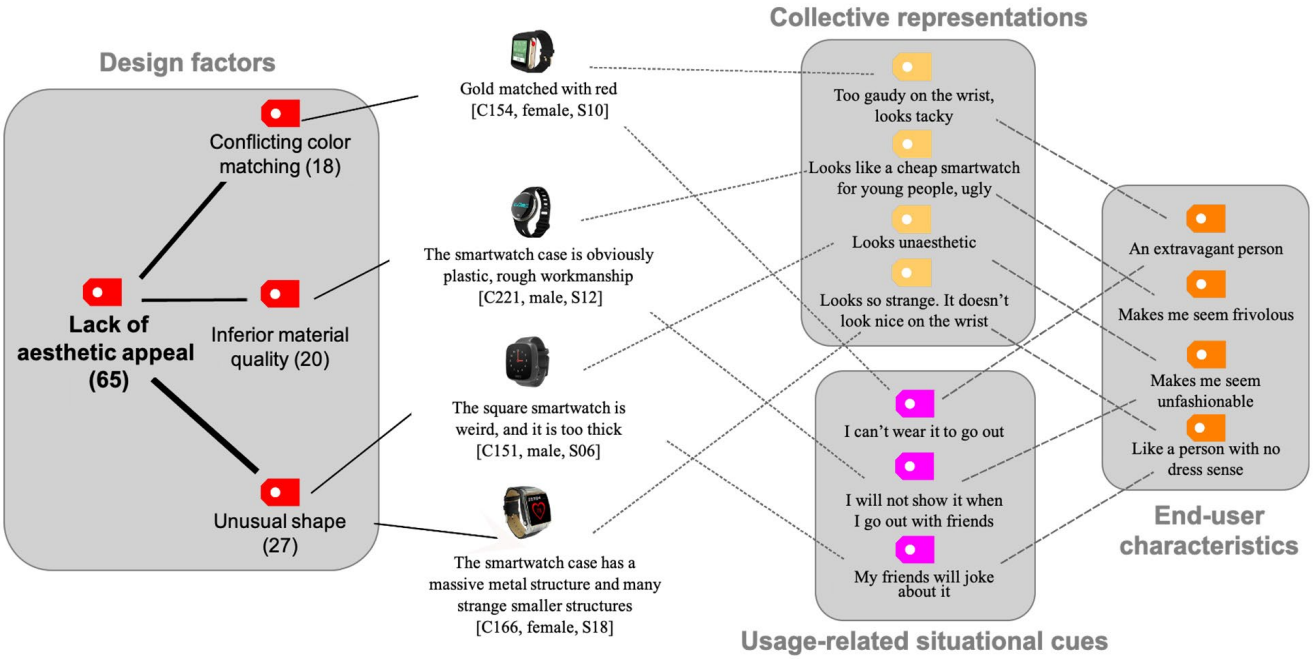

Figure 6. Coding structure and context examples in the axial code of lack of aesthetic appeal.

Table 2. Open codes and context examples in the axial code of lack of aesthetic appeal.

Open Codes	Total	Open Code Examples in Context
01 Conflicting Color Matching	18	"…. *Gold matched with red* **(Conflicting color matching)**, too gaudy on the wrist, looks tacky **(Collective representations)**, I can't wear it outdoors **(Usage-related situational cues)** … It makes me seem like an extravagant person **(End-user characteristics)**." [C154]
02 Inferior Material Quality	20	"*The smartwatch case is obviously plastic, rough workmanship* **(Inferior material quality)**, it looks like a cheap gadget for young people, ugly **(Collective representations)**, makes me seem frivolous **(End-user characteristics)**, I will not show it when I go out with friends **(Usage-related situational cues)**." [C221]
03 Unusual Shape	27	"*The smartwatch case has a massive metal structure and many strange smaller structures* **(Unusual shape)**, it looks so strange. It doesn't look nice on the wrist **(Collective representations)** … Like a person with no dress sense **(End-user characteristics)**." [C166] "*The square smartwatch is weird, and it is too thick* **(Unusual shape)**, looks unaesthetic **(Collective representations)**, my friends will joke about it **(Usage-related situational cues),** makes me seems unfashionable **(End-user characteristics)**." [C151]

Accentuated Social Signifiers

Norman (2008) described a *social signifier* as a social-usage-related indicator or signal which can be interpreted meaningfully and is able to convey information intentionally or unintentionally. Usually, social signifiers involve information that design must provide, and can assist users and social culture in understanding products and services. However, social signifiers particularly emphasized by designers may induce stigma perception in older adults. Our study results showed that the participants identified three types of accentuated social signifier (Figure 7 and Table 3): *obvious instructions* ($n = 12$), *pattern with special meaning* ($n = 11$), and *typical gerontic styles* ($n = 22$). Among *obvious instructions*, the older adults most often mentioned an "SOS button" which was specially emphasized by the designers with vivid colors, with the consequence that the social culture would see the smartwatch as a medical device designed for frail and sickly older adults. Hence, others would have an attitude of sympathy for the older adult and underestimate their ability to use technology, thus labeling the older adult as not tech-savvy and causing them to be shy of showing the device. In addition, the accentuated social signifier *pattern with special meaning* was a key factor in inducing stigma. For example, smartwatch S01 presents a QR Code on its face and was immediately recognized by the older adults as an aid to finding the wearer if they go missing, and was therefore associated with dementia-related stigma. At the same time, older adults were sensitive in perceiving some design features frequently used by designers in gerontechnology, which we collectively characterize as typical gerontic styles. For example, S01, with its substantial size and large buttons, was deemed to be a typical gerontic style for elderly users with severe vision impairment and poor ability to use a touch screen, which, no matter whether the designers truly underestimated the ability of older adults to use technology, would attach a negative label to older adults, and would make older adults ashamed of showing the smartwatch or lead to their simply not using it. Such accentuated social signifiers were mainly introduced with good intentions by the designers in the hope that older adults could conveniently use the smartwatches in different life situations, but instead they became a burden to older adults in their everyday social lives, hindering their acceptance of the devices.

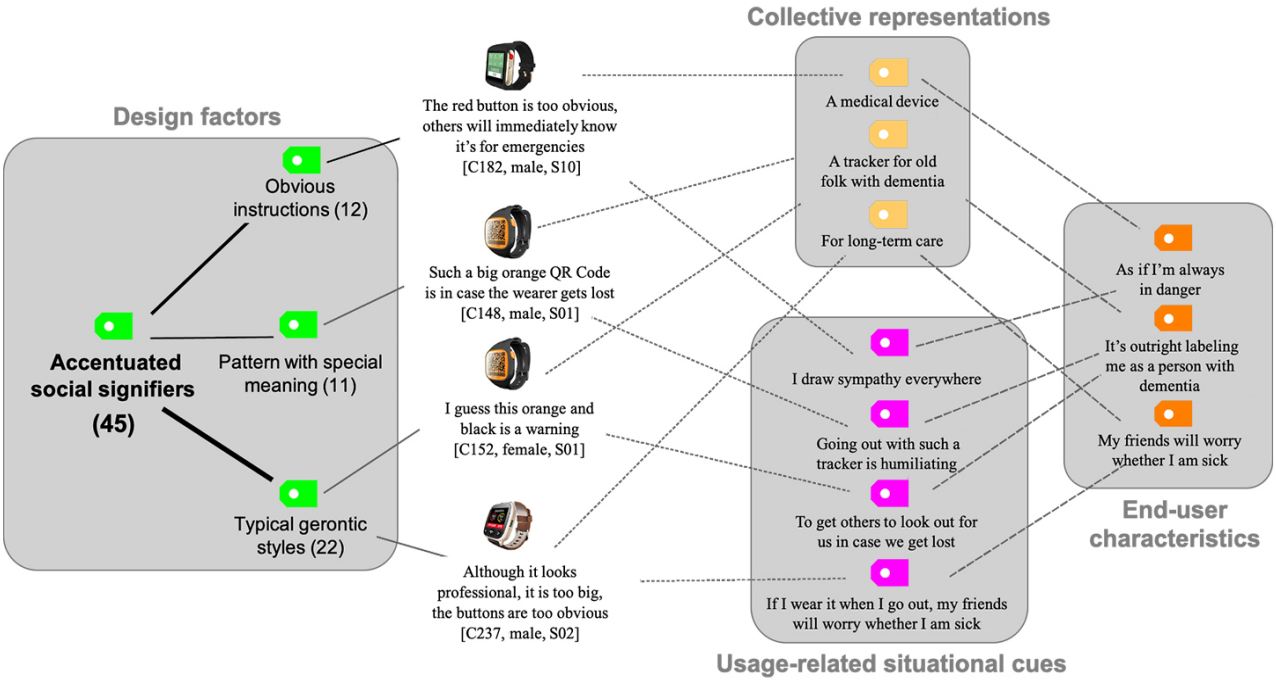

Figure 7. Coding structure and context examples in the axial code of accentuated social signifiers.

Table 3. Open codes and context examples in the axial code of accentuated social signifiers.

Open Codes	Total	Open Code Examples in Context
01 Obvious Instructions	12	"*The red button is too obvious, others will immediately know it's for emergencies* **(Obvious instructions)**, as if I'm so old that I'm always in danger **(End-user characteristics)** and need a medical device **(Collective representations)**, I draw sympathy everywhere **(Usage-related situational cues)**." [C182]
02 Pattern with Special Meaning	11	"*Such a big orange QR Code is in case the wearer gets lost* **(Pattern with special meaning)**, it's outright labeling me as a person with dementia **(End-user characteristics)**, going out with such a tracker is humiliating **(Collective representations) (Usage-related situational cues)**." [C148]
03 Typical Gerontic Styles	22	"Although it looks professional, *it is too big, the buttons are too obvious* **(Typical gerontic styles)**, like I have a disease requiring long-term care **(Collective representations)**. If I wear it when I go out, my friends will worry whether I am sick **(End-user characteristics) (Usage-related situational cues)**." [C237] "A tracker for old folk with dementia **(Collective representations)**, *I guess this orange and black is a warning* **(Typical gerontic styles)**, to get others to look out for us in case we get lost? **(Usage-related situational cues)** People around me will think I have dementia **(End-user characteristics)**." [C152]

Poor Affordance

Affordance is an inherent design attribute of a product. Its role is to provide the opportunity for the user to directly perceive how an object can be interacted with (Kannengiesser & Gero, 2012; Norman, 2013). Affordance is about what older adults need to do and is used by designers to amend the attributes and exterior layout of objects to map them to usage by older adults. At present, designers of gerontic smartwatches are eager to integrate multiple functions into these devices. However, not all functions are at a mature enough stage of development, and not all are acceptable to older adults in their life situations. Our coding marked *unoptimized use procedure* (n = 18) and *low acceptance of use procedure* (n = 27) to capture such situations (Figure 8 and Table 4). Unoptimized use procedures result from poor mapping of user actions for certain functions. For example, some smartwatches need to be held level with the heart for some time when taking blood pressure, and this action attracts attention from people nearby, which embarrasses older adults. This is caused by immature technology that is not user-friendly. Low acceptance of use procedure arises from the inclusion of functions that are unnecessary for older adults, involving usage behaviors that have not yet been accepted by social culture or are unable to be accepted. In this study's cultural probe of smartwatches, some participants said they were accustomed to a watch as a relatively static accessory, which did not need to attract too much attention or require too much interaction. From this it can be inferred that it would be better if health monitoring function modules are hidden under a static appearance, and that the device's operation mode should also be hidden as far as possible. It seems that older adults need this kind of semantic consistency in HMWs. If a smartwatch requires too many obvious and frequent user actions, this will be regarded as abnormal and will attract excessive attention and interpretation from bystanders, which is embarrassing for older adults. For example, the older adults explained that the stigma perception of the call-supporting smartwatch lies in the fact that they have to speak into the smartwatch every time they receive a phone call, or place the smartwatch next to their ear to hear the caller, which is often misinterpreted as showing off by people nearby, forcing older adults to end the call to avoid too much negative attention.

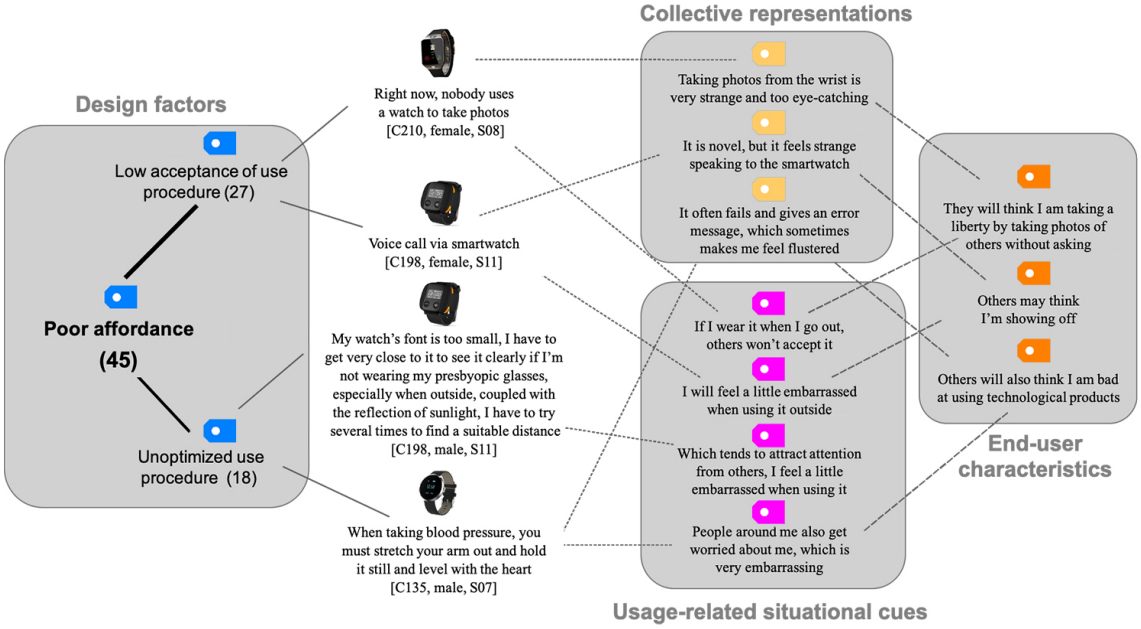

Figure 8. Coding structure and context examples in the axial code of poor affordance.

Table 4. Open codes and context examples in the axial code of poor affordance.

Open Codes	Total	Open Code Examples in Context
01 Unoptimized Use Procedure	18	"*When taking blood pressure, you must stretch your arm out and hold it still and level with the heart* **(Unoptimized use procedure)**, and it often fails and gives an error message, which sometimes makes me feel flustered **(Collective representations)**. People around me also get worried about me, which is very embarrassing **(Usage-related situational cues)**, and others will also think I am bad at using technological products **(End-user characteristics)**." [C135] "*My watch's font is too small, I have to get very close to it to see it clearly if I'm not wearing my presbyopic glasses, especially when outside, coupled with the reflection of sunlight, I have to try several times to find a suitable distance* **(Unoptimized use procedure)**, which tends to attract attention from others. I feel a little embarrassed when using it **(Usage-related situational cues)**." [C198]
02 Low Acceptance of Use Procedure	27	"*Voice call via smartwatch* **(Low acceptance of use procedure)** is novel, but it feels strange speaking to the smartwatch **(Collective representations)**, I will feel a little embarrassed when using it outside **(Usage-related situational cues)**, others may think I'm showing off **(End-user characteristics)**." [C198] "Right now, *nobody uses a watch to take photos* **(Low acceptance of use procedure)**, taking photos from the wrist is very strange and too eye-catching **(Collective representations)**. If I wear it when I go out, others won't accept it **(Usage-related situational cues)**, they will think I am taking a liberty by taking photos of others without asking **(End-user characteristics)**." [C201]

Neglect of Privacy

A unique design feature of HMWs is that they can track and convert users' health information in real time (Chan, Estève, Fourniols, Escriba, & Campo, 2012). Privacy is a key issue of concern for end-users when they feel stigmatized (Li, Wu, Gao, & Shi, 2016). Stigma-induced sensitivity to privacy is closely linked to the autonomy of older adults in their daily activities and to their decision-making power regarding personal information. Two design features were extracted to explain privacy-related stigma perception (Figure 9 and Table 5): *interference in freedom of daily activities* (n = 16) and *involuntary data connection* (n = 19). Older adults are deeply concerned about whether they will need care or will become sick and frail, and they care not only about what non-family members think, but even more about what their own children think. Some data are recognized as private by older adults, such as their sphere of everyday activities and some health data. If family members gain free access to private data, older adults will lose their sense of accomplishment and sense of freedom, thus inducing stigma perception. Moreover, if children's monitoring of the older adults in their family is known about by outsiders, the older adults' stigma perception will be stronger; and they will think of themselves as needing care or as having lost autonomy in their daily living, and so will develop a strong sense of inferiority.

Discussion

A perfect HMW design enables the product and the services it provides to function smoothly in accordance with the older adult's perception. But stigma interrupts this ideal, so it is crucially important to identify the design factors that induce stigma perception. In past research, the problem of design-induced stigma perception in older adults has been a very vague issue, and some researchers have considered that stigma issues exist only in a few failures of prototyping and extreme cases. But the findings of this study show that stigma perception is ubiquitous in mature gerontic HMWs, with differing levels of frequency. Older adults' inherent prejudice against HMWs, combined with their experience in usage situations, causes them to project a negative evaluation of end-user characteristics and thus to identify the use of HMWs as a threat to their own social identity. This is also the process by which their stigma perception is induced.

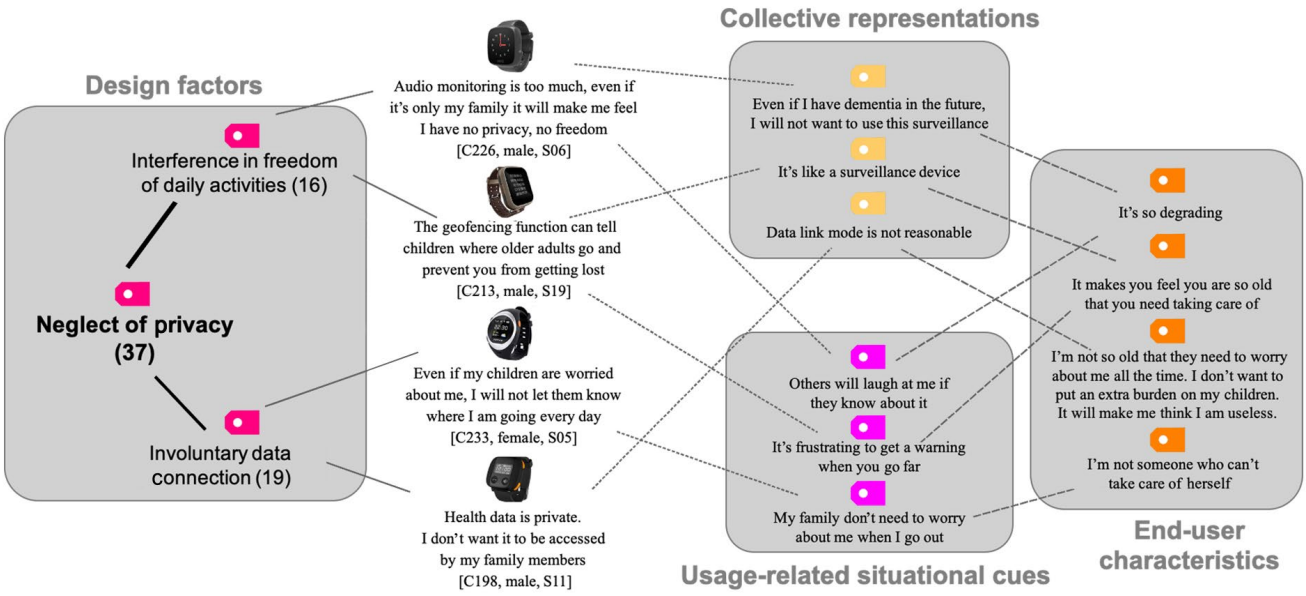

Figure 9. Coding structure and context examples in the axial code of neglect of privacy.

Table 5. Open codes and context examples in the axial code of neglect of privacy.

Open Codes	Total	Open Code Examples in Context
01 Interference in Freedom of Daily Activities	16	"*The geofencing function can tell children where older adults go and prevent you from getting lost* **(Interference in freedom of daily activities)**, but I think it is unnecessary, it's frustrating to get a warning when you go far **(Usage-related situational cues)**, it's like a surveillance device **(Collective representations)**. It makes me feel like they think I'm so old that I need taking care of **(End-user characteristics)**." [C213] "*Audio monitoring is too much, even if it's only my family it will make me feel I have no privacy, no freedom* **(Interference in freedom of daily activities)**, and others will laugh at me if they know about it **(Usage-related situational cues)**. Even if I have dementia in the future, I will not want to use this surveillance **(Collective representations)**, it's so degrading **(End-user characteristics)**." [C226]
02 Involuntary Data Connection	19	"The data link mode is not reasonable **(Collective representations)**. *Health data is private. I don't want it to be accessed by my family members* **(Involuntary data connection)**. I'm not so old that they need to worry about me all the time. I don't want to put an extra burden on my children. It will make me think I am useless **(End-user characteristics)**." [C198] "*Even if my children are worried about me, I will not let them know where I am going every day* **(Involuntary data connection)**. They should be able to understand, I am still healthy, my family don't need to worry about me when I go out **(Usage-related situational cues)** … I'm not someone who can't take care of herself **(End-user characteristics)**." [C233]

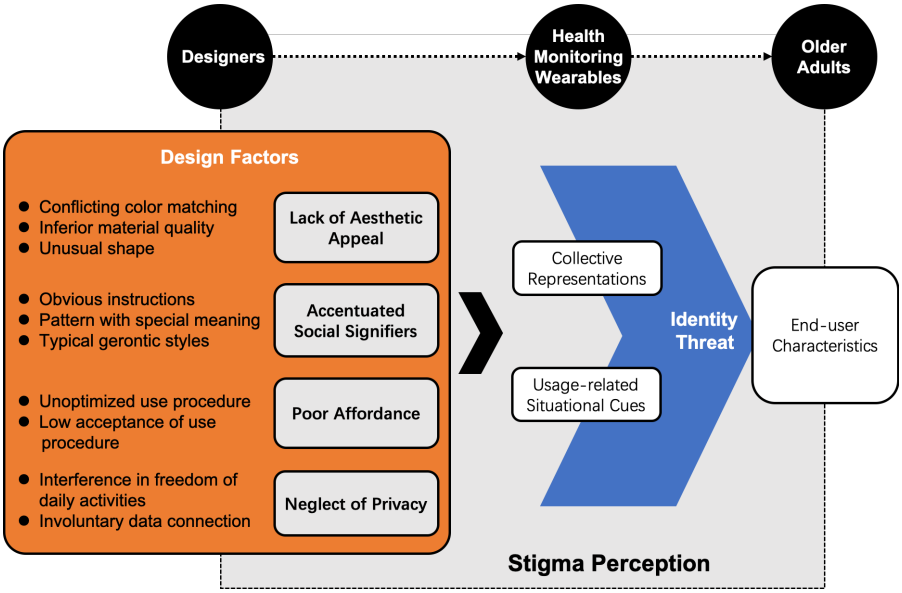

Figure 10. Conceptual model of stigma perception in a design domain.

This study finally generalizes four stigma-inducing design factors and their design features to reveal the sources of stigma perception in the HMW design domain (Figure 10). It reveals that although the technology is evolving at a fast pace, rules can be found for design features that are displeasing to older adults, and designers who are involved in the creation of physical products and intangible services in this domain are able to recognize and avoid these undesirable design features. Although the deconstruction of stigma perception in this study derives from the analysis of health monitoring smartwatch samples, these four design factors can be extended to broader HMW and gerontechnology design. The following issues behind problematic design factors in design for older adults deserve critical reflection by designers:

First, the *lack of aesthetic appeal* perspective reflects the need for the designer to grasp older adults' habits in their aesthetic judgments regarding technological products. For many years, aesthetic appeal has often taken second place to ease of use in design decisions, but aesthetic appeal seems to be highly relevant to stigma issues (Xenakis & Arnellos, 2013). Compensation models based on limitations in the abilities of older adults are highly likely to dominate in design, leading to neglect of aesthetic appeal (Dobson et al., 2015). This study found that conflicting colors, inferior material quality, and unusual shape were design features that older adults pointed out and deemed to be unattractive, showing that older adults' perceptions of aesthetic appeal in a product are different from young people's taste for novel technology. This suggests that for technologies such as HMWs that are designed in the form of clothes and accessories, older adults are more sensitive to what is considered "beauty" and perceptions of social identity. Hence, design features such as color, material quality, and form need to reflect mainstream aesthetic tastes, with detailed design that embodies social appropriateness and a sense of quality.

Second, the *accentuated social signifiers* perspective reflects the need for designers to understand the social identity signifiers to which older adults are sensitive. All people have an identity within their social system. In current society, older adults encounter negative influences of aging, which leads to more negative, stereotyped images being applied to them (Fisk, Rogers, Charness, Czaja, & Sharit, 2009), so they are extremely sensitive to degradative identity signifiers (Bai, Lai, & Guo, 2016; Ziefle & Schaar, 2017). This study found that sensitive signifiers for older adults are obvious instructions intended to cater to older adults' abilities to use technology, signifiers indicative of dementia and waning memory, and typical gerontic styles featuring big buttons and large devices, which are all associated with reduced ability to use technology and declining cognitive skills due to senescence. Designers should identify and weaken these signifiers, and replace them with signifiers pertaining to positive images of older adults. Krippendorff (2006) pointed out that semantics is the new foundation of product design, and the interface design of products should follow their recognizable meaning. Vaes (2014) proposed in his model that the influence of stigma can be reduced by strengthening a product's individual identity, institutional identity, group identity, and brand identity (p. 175); moreover, previous studies have also shown that bad cultural signifiers can be semantically transformed. This study found that many elderly people enjoy custom-made accessories or cherish jewelry in their lives; designers can try to explore older adults' perceptions of such appreciated objects, to design HMWs that create a more positive interaction with them.

Third, the *poor affordance* perspective reflects the question of whether it is necessary to design technology that covers all aspects of older adults' usage behavior in their daily activities. Currently, designers of HMWs are eager to integrate multiple functions, but overlook reasonable use procedures (Page, 2015). For example, procedures for taking blood pressure that are overly eye-catching or are likely to be carried out incorrectly could be better optimized. And although providing functions such as the ability to use the smartwatch to make voice calls and take photos may seem considerate, these modes of use have not yet been accepted by the general public. Hence, the issue of poor

affordance should encourage designers to rethink the value of technology for older adults. Abnormal use procedures and stigma perception are inseparable, making older adults seem overly dependent on technology, or creating the impression that they are showing off, which lead to a negative outlook on life. Therefore, technological support for older adults is not about quantity or multiple functions, but embedding what is reasonable for older adults to function normally in their social environment.

Fourth, the *neglect of privacy* perspective reflects the need to strike an appropriate balance between providing care and support, and avoiding intrusion. Designers should pay careful attention to the fact that HMWs bring more privacy-related issues for older adults. Stigma perception around privacy issues derives from designers' ethical attitudes towards gerontechnology, that is, whether technological devices to assist healthy aging should take account of possible future pathological changes such as dementia, and thus predetermine the approach to home care. China advocates the culture of filial piety and has a tradition of respecting and taking care of older adults. However, in recent years, because many young people in cities and towns go out for work and the dependency ratio is rising, the aging of the population has become a new social burden. The trend for the new generation taking care of their parents is expressed through modern technology and social networks rather than in the traditional face-to-face way. However, older adults are highly sensitive to some so-called innovative usage habits such as being warned by a geofence or their phone calls being monitored by their children. Older adults tend to think of independence and autonomy in daily life as being more important than health monitoring, and even if such functions are not activated, they nonetheless induce strong stigma perception in older adults. Even the participant in this study with mild dementia did not like their life being controlled by their family. Consequently, designers need to rethink the value of privacy for older adults and their family, and judge whether older adults are willing to give up a certain degree of privacy to acquire specific benefits (Li et al., 2016).

Conclusion

Stigma perception among older adults is a major barrier to the design of health monitoring wearables to assist healthy aging. Using smartwatches as examples of HMWs, this study aimed to gain an overall picture of older adults' stigma perception through a large number of case studies, and to identify the design factors and features that induce such stigma. The identity threat perspective in social psychology provides an effective reference to deconstruct stigma perception. The quantitative statistics of stigma perception relating to this study's test samples shows that stigma perception is widespread with regard to existing mature HMWs and that different devices induce stigma perception with different levels of frequency. Lastly, using backtracking, the researchers encoded and analyzed collective representations, usage-related situational cues, and end-user characteristics associated with HMWs by older adults, and generalized the design features involved into four design factors: first, lack of aesthetic appeal, deriving from the design features of conflicting color matching, inferior material quality, and unusual shape; second, accentuated social signifiers, deriving from obvious instructions, pattern with special meaning, and typical gerontic styles; third, poor affordance, deriving from unoptimized use procedures, and low acceptance of use procedures; and fourth, neglect of privacy, involving interference in freedom of daily activities, and involuntary data connection. The design factors identified above reflect how in gerontechnology design, designers have problems and misunderstandings with regard to four aspects: the aesthetic preferences of older adults, sensitive identity signifiers, acceptability of usage behaviors, and the balance of privacy rights within the family. We suggest that through a greater understanding of stigma, designers can reflect on how to apply empathic design, so as to enable gerontology design to better support the well-being of older adults. We believe that stigma-related design factors can be addressed through product semantics and other strategies proposed in previous research. Product semantics provides us with some possible solutions; for example, we learned that some older adults cherish the high-end smartwatches or beautiful jewelry that they wear in their daily lives. Designers may wish to emulate the excellent quality and familiar shapes of such items when designing HMWs, which should enhance older adults' appreciation of the devices. To diminish stigma perception, designers need to rethink the appearance of HMWs from multiple perspectives, including semantics, ethics, social stereotypes, cultural image, social interactions, and service experience, to enable gerontechnology to enhance the well-being of older adults.

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Appendix

The appendix shows the specifications of all 30 health monitoring smartwatches used as stimulus material samples in the sentence completion task.

	Graphic	Function Brief		Graphic	Function Brief		Graphic	Function Brief
S01		Location tracking, SOS assistant, Emergency contact, QR code	S08		GPS, Music, Health monitoring, Voice communication, Sound recording, Camera	S15		Health monitoring, Location tracking, SOS assistant, Emergency contact, Call alert
S02		Blood pressure monitoring, Voice communication, SOS assistant, Location tracking, Pedometer	S09		Voice communication, Location tracking, Radio, Weather forecast, SOS assistant	S16		Location tracking, Alarm, Heartbeat detection, SOS assistant
S03		GPS, SOS assistant, Emergency contact, Blood pressure monitoring, Sleep monitoring	S10		Blood pressure monitoring, GPS, Heartbeat detection, SOS assistant, Voice communication	S17		Medication reminder, Voice communication, SOS assistant, GPS, Fall detection, Health monitoring, Pedometer
S04		Voice communication, Pedometer, SOS assistant, Emergency contact, Remote monitoring for family	S11		GPS, SOS assistant, Voice communication, Alarm clock, Remote monitoring for family, SOS assistant, Medication reminders	S18		Location tracking, Heartbeat detection, SOS assistant, Emergency contact, Remote monitoring
S05		Fall detection, Remote health monitoring, GPS, Emergency contact	S12		Blood pressure monitoring, Exercise log, Music, Message alert, GPS	S19		Geofencing, SOS assistant, Emergency contact
S06		Location tracking, SOS assistant, Remote sound monitoring	S13		Remote monitoring, SOS assistant, Emergency contact, Health monitoring, Camera	S20		Health monitoring, Sedentary alert, SOS assistant, Voice communication
S07		Voice communication, Heart rate monitoring, Pedometer, Message reminder, Weather forecast	S14		Health monitoring, Voice communication, SOS assistant, GPS			