The Development and the Wearability Assessment of Cliff: An Automatized Zipper

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***Abstract*—Cliff is a project which aims to develop an automatized zipper for the zipping and unzipping process. It is a response to the struggle by the elderly, people with physical disabilities and, ladies who have problems zipping back-zipper dresses. An iterative research through design approach was applied [1] to develop a working mechanism and prototype of Cliff. In order to assess the general comfort level of Cliff, the Comfort Rating Scales (CRS) method has been used. It measures the wearable comfort across six dimensions: emotion, attachment, harm, perceived change, movement and anxiety [2]. The user participatory design session has been designed and conducted to perform the study which includes a session of observation, prototype experience, a survey, and open questions. The test results show that the acceptance of the Cliff is satisfactory with all the levels of effect scoring at the lowest level. However, the findings also raised concerns about the stigmatisation effect. This study provided useful insight, opinions and, feedbacks which are essential to make Cliff ready for society.**

***Index Terms*—automatized zipper, robotic, wearability assessment, research through design**

I. Introduction

A zipper can be seen on numerous kinds of garments such as on jackets and dresses. It is generally acknowledged as the clasp locker. The chronology of the zipper invention begins in 1851, when Elias Howe, the inventor of the sewing machine, received a patent for an automatic, continuous clothing closure [3]. In 1893, Whitcomb L. Judson became the first person to invent, and conceive the idea of a slide fastener and develop the working zipper [4]. The development endured when in 1913, Gideon Sunback, an electrical engineer designed the modern zipper and patented a design entitled ‘separable fastener’ in 1917 [5]. The design increased the number of fastening elements, introduced two-facing rows of elements that pulled into a single piece by the slider and expanded the opening for the elements guided by the slider. Twenty years later, the B.F Goodrich company decided to use Gideon's fastener on a rubber boot and named the device as ‘zipper’ [6].

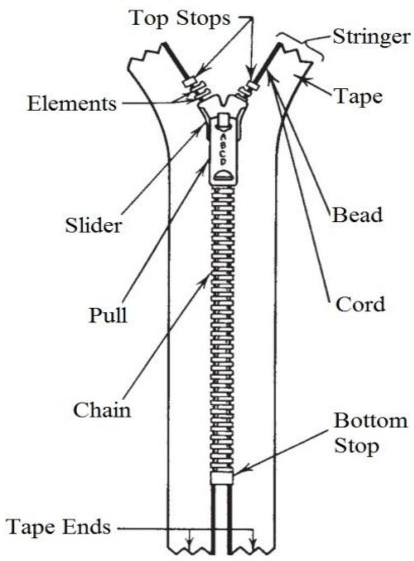

Figure 1. Principal parts of the zipper [7]

Fig. 1 shows the principal parts of the zipper and standard terminology of the subassemblies of the zipper based on the ASTM D2050-04 standard [7]. Although the zipper is a simple device to operate, not everybody can perform the zipping and unzipping process efficiently and independently. People who are unable to zip or unzip themselves will require assistance from others to perform the task. The back closures are a typical fastening method on garments for all ages such as dresses, skirts and, blouses. A back closure system means that the wearer will have to fasten their garment at the rear, with the use of a zipper, hook-and-eyes or buttons. Fashion designers often favour this back closure for couture and formal wear, where the aesthetic value is essential. However, the back closure has its advantages and drawbacks. A back closure dress offers the wearer a quick enter and exit from the garment from the rear, especially for a dress that is tightly fitted and does not stretch. The most obvious drawback of the back closure is the difficulty to reach the middle of the wearer’s back and manipulate the fasteners to close their dress. Hence, the wearer might need support donning or doffing their dress. If they keep trying on their own, it could be time-consuming to wear or remove the dress.

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Therefore, the motivation to develop Cliff, an automatized zipper, is a response to the struggle of the few groups of individuals such as the elderly and ladies who have problems zipping a back-zipper dress [8]. The aim of this project is to create greater benefits for society to ease the zipping and unzipping process. This project was inspired by Adam Whiton, who build the first robotic zipper recognised as the Zipperbot [9]. The Zipperbot did not use the slider of the zipper to zip or unzip, which makes it a non-generic system and explains its weakness. However, this newly-designed automatized zipper tried to retain the zipper's structure as it is and develop a generic and universal type of this robot. This project is also motivated by an article written on actuating movement in refined wearables [10]. Cliff could be another new device in the world of wearable technology and the "future of fashion"[11]. The construction of the automatized zipper is going through the iterative research through design process which managed to develop four different prototypes in each design iterations. [1]

This paper presents the design iterations during the early development stage of the automatized zipper. The research through design process is performed to develop the working mechanism of Cliff. Besides that, this paper also discusses the result from the preliminary user study with a group of elderly people. The user study measures the wearability assessment on general comfort towards the automatized zipper. The evaluation used the Comfort Rating Scales (CRS) method [2,12]. Since we are in the early design stage, this study is essential to gain feedback on Cliff from the elderly. It also aims to dig deeper into the responses from older adults on their feelings and featured preferences towards this automatized zipper.

II. PROTOTYPING OF CLIFF

The prototyping approach helps the designers transform their creative translation of research and innovative ideas into a tangible form. The prototype is essential for the testing of concepts by the designer, design team, clients and the potential users. By making prototypes, designers simultaneously discover how to approach the problem at hand. Every design prototype is defined by its level of fidelity or resolved finish. The low-fidelity prototype is commonly used during the early ideation processes, such as by making sketches or storyboards [13]. Through an iterative process, it is easier to approach complex design challenges using multiple cycles. The perfect solution in any design case doesn't have to happen in the first shot. The design exploration cycle is not only a thought process but also produces lots of new knowledge and information. Creating tangible solutions that can be experienced are essential throughout the design process to validate ideas and guide further developments. The physical form is the high-fidelity prototypes that are more refined, with the looks and appearance of the final product evident. It can also be felt and sometimes, comes with basic functionality [13]. Iterative research through design involves making and reflection. It allows creating a dialogue with the material and helps the designer and stakeholders envision future applications with the prototypes. Touching materials and demonstrators are also important in order to talk to (potential) stakeholders and convince the people in the boardroom [1].

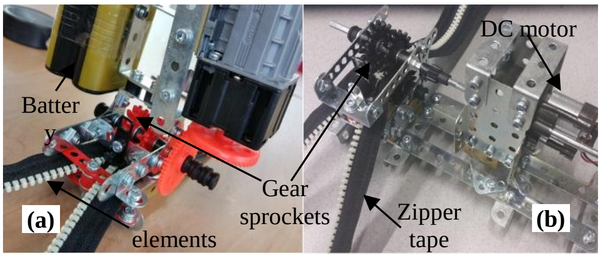

Figure 2. The prototype build from Meccano: (a) first iteration (b) second iteration.

The first iteration for the automatized zipper project begins with exploring the potential traction mechanism using the Meccano after understanding the physics and mechanics of the zipper as reported in [14]. Meccano is a toy consisting of a set of plastic and metal parts which enables the building of working models, mechanical devices or prototypes [15]. The aim of this iteration is to identify the mechanism that can generate traction to move the zipper tape since the slider is fixed on the Meccano structure as shown in Fig. 2. The main challenge here is to develop a generic and universal type of traction mechanism which can be used in all kind of zippers. After two months of trial, the first iteration of this project works as shown in Fig. 2(a). The dimension of this prototype is 61 x 35 x 50 mm. It used two gear sprockets as traction mechanism on both sides of the tape to establish the uniform distribution of normal force acting towards the zipper tape as shown in Fig. 3 [14]. The gear tooth grabs the zipper tape. The weaknesses of this first iteration prototype are with regard to stability, it produces vibrations during its operation. Secondly, the gears used to connect the DC motor and the rotating wheels could easily misalign. Moreover, this first iteration is too bulky, and heavy and look like metal. Therefore, it is not convenient to be attached to garments.

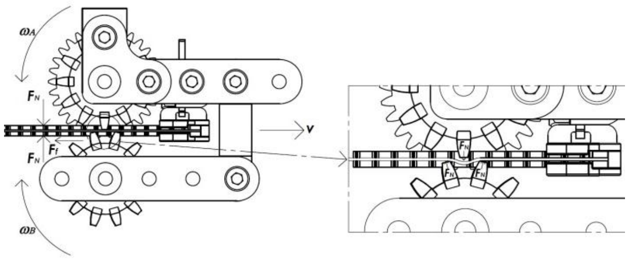

Figure 3. The traction mechanism of Cliff

Fig. 2(b) shows the second iteration prototype. The goal of the second iteration is to stabilise the overall structure compared to the first one. The stability of the prototype is essential to evaluate and observe correctly why and how this mechanism works. The DC motor has now been placed on the side of the rotating wheels instead of on top of the rotating wheels, as in the first iteration. Changing the position of the DC motor improves stability, movement and, performance. Through close observation, we found that the gear sprocket from the top and bottom of the prototype make contact with the zipper tape surface and generate traction. However, this prototype is still too big to be placed on garments, and still looks metal.

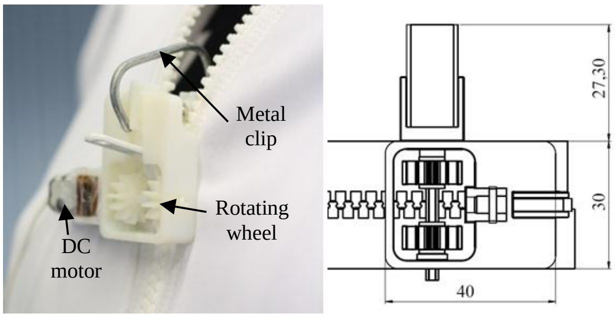

Figure 4. Third iteration prototype (miniature model).

The development of this automatized zipper then entered the miniaturisation stage. At this juncture, the aim is to produce a miniature model that can run on a jacket designed by Marina Toeters. Shown in Fig. 4 is the third iteration prototype on the jacket. The DC motor was placed on the side of the top chassis, and the motor shaft is parallel to the rotating shaft of the traction wheels. The selection process of this DC motor has been made after performing the kinematic analysis to determine the suitable DC motor that can drive the robotic zipper based on the forces on this system [14]. The design for this third iteration functions like a detachable piece, which separates the top and bottom chassis. Both sides of the chassis are joined through a screw, and slotted in the middle, which allows it to act like a clip. It offers flexibility where you can quickly put on and remove Cliff from your garments. Another significant finding on this third iteration is the need for a sufficiently high normal force to clamp the top and bottom chassis together and ensure that the fabric engages between the two rotating wheels. Ensuring traction is crucial. Therefore, a metal clip is slotted in at the front of Cliff as illustrated in Fig. 4. The metal clip provides the normal force to the top and bottom chassis, to make sure the fabrics of the jacket are in contact with the traction wheels, thus generating friction and producing excellent traction for the zipping and unzipping process.

Even though the third iteration prototype works well, there remain a few aspects that need to be improved. The DC motor position on the side of the chassis causes imbalance during the movement and could lead to misalignment of the rotating wheels. Moreover, this prototype does not include a switch and battery, attached to the structure as a single complete unit. However, this third iteration is a significant achievement of this project since we managed to develop the miniature model of Cliff in size (40 x 57.3 x 25 mm) compared to the previous two iterations.

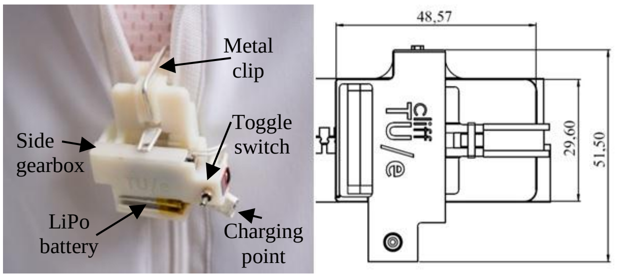

Figure 5. Fourth iteration prototype.

Fig. 5 shows the fourth iteration of Cliff. The aim of this iteration is to build a single unit of Cliff, with the switch and battery attached to it. The DC motor is placed on top of the wheels and connected through a vertical side gearbox. Two pieces of 3.7V LiPo battery are used to power the 6V DC motor, and there is also a battery charging point installed. The installation of the charging point is the reflection on middle ground care and maintenance requirements which the consumers are accustomed to given types of maintenance interaction with the technology such as the charging part [11]. A three poles toggle switch is used to control the system as the switch provides functions to the ON(unzipping) – OFF – ON(zipping). The fourth iteration prototype works well, but not for an extended period, due to the reliability issue of the tiny gears on the side gearbox. Since we 3D printed those gears, the material is not strong enough to perform the operation, and the gears break. The mechanism of this iteration works nicely. Therefore, the construction of the next iteration will use other materials instead of the plastic material. Lightweight metals could be an option to replace this plastic material. However, the material needs to be chosen properly since technological components might be stiffer and heavier, which when integrated into clothing, could create swinging masses or digging edges on the clothing or the body [16]. This will result in discomfort and restricted movement or fatigue for the user.

III. User Study

The preliminary user study conducted is regarding the wearability assessment of Cliff. The aim of this study is to evaluate the acceptance of Cliff among the target group which is the elderly using the wearability assessment tool [2]. Besides that, it also seeks to dig more on the responses from the seniors on their feelings and features preferences towards the automatized zipper.

A. *Wearability Assessment*

The accomplishment of developing any wearable or solutions based device relies not only upon technical or technological advancement, but also on the final user acceptance [17]. According to Gemperle et al., the wearable term is defined as implying the use of the human body as a support for some product [18]. When wearing something on our body, the level of comfort of the individuals can be affected by a few factors, such as the device's size and weight, how it affects movement, and direct or indirect pain [2]. Knight et. al. present a tool

(Comfort Rating Scales (CRS)) that measures wearable comfort across six dimensions as described in Table I.

TABLE I. THE CRS QUESTIONNAIRE [2]

Dimension	Question Code	Description
Emotion	E1	I feel worried and embarrassed.
	E2	I feel tense.
	E3	I would wear the device if it was invisible.
Attachment	A1	I feel the device on the body.
	A2	I feel the device moving.
	A3	I was not able to move as usual.
	A4	I have difficulty in putting on the device.
Harm	H1	The attached device cause me some kind of harm.
Perceived Change	PC1	I feel more bulky.
	PC2	I feel change in the way people look at me.
Movement	M1	The device obstructs my movements.
Anxiety	AX1	I do not feel secure with the device.
	AX2	I feel that I do not have the device properly attached.
	AX3	I feel that the device is not working properly.

The application of this approach is to function as an aid to designers and researchers to evaluate the wearability, regarding the general comfort of the wearable computers. The CRS is constructed based on the six dimensions of comfort to be assessed, which are emotion, attachment, harm, perceived change, movement, and anxiety. This tool has been tested to examine the wearability of four different kinds of wearables; the Sense Wear, Hot Helmet, Scott Glove and the Web Enhanced Context Aware Personal Computer (WECAPC). From the results, they found that the CRS is suitable to measure the level of comfort specific to the comfort dimension and to make comparisons between devices [2].

The CRS method has also been applied by Sotiriou et. al. to assess the wearability of the CONNECT mobile Augmented Reality (AR) system [19]. CONNECT is a project to develop an innovative pedagogical framework which aimed to blend the formal and informal learning, proposing an educational reform to science teaching. This tool has also been used to evaluate a wearable computer system designed at the intensive care unit (ICU) of a hospital [20]. By using the CRS, Weller et. al found that the male participants feel self-conscious while wearing the wearable device, while the female respondents felt awkward with it as the device affected their movement.

TABLE II. GENERAL DESCRIPTION OF EACH GENERAL COMFORT DIMENSION.

Dimension	Endpoints	Description
Emotion	Low	I am worried about how I look when I wear this device.
	High	I do not feel tense or on edge because I am wearing the device.
Attachment	Low	I cannot feel the device on my body. I cannot feel the device moving.
	High	I can feel the device on my body. I can feel the device moving.
Harm	Low	The device is not causing me some harm. The device is not painful to wear.
	High	The device is causing me some harm. The device is painful to wear.
Perceived Change	Low	Wearing the device did not makes me feel physically different. I do not feel strange wearing the device.
	High	Wearing the device makes me feel physically different. I feel strange wearing the device.
Movement	Low	The device did not affects the way I move. The device is not inhibits or restricts my movement.
	High	The device affects the way I move. The device inhibits or restricts my movement.
Anxiety	Low	I do feel secure wearing the device.
	High	I do not feel secure wearing the device.

The CRS used a 21-point scale anchored at each end with the labels “low” and “high” (low (0-4), Moderate (5-8), Large (9-12), Very Large (13-16), Extreme (17-20)). Table II describes the general description of each general comfort dimension. According to Knight and Baber, this range was considered sufficient to extract a broader response that is beneficial for detailed analysis. The participants will only mark the score on the scale for his/her level of agreement with each statement for every group of the comfort dimension. Knight and Baber devised these statements based on the interpretation of the aspect of comfort each dimension conveyed. From the Low to Extreme level of effect, five Wearability Levels (WL) can be suggested which are [12]:

- WL1 (Low level) - System is wearable (CRS score: 0-4).
- WL2 (Moderate level) - System is wearable, but changes may be necessary, further investigation needed (CRS score: 5-8).
- WL3 (Large level) - System is wearable, but changes are advised, uncomfortable (CRS score: 9-12).

- WL4 (Very Large level) - System is not wearable, fatiguing, very uncomfortable (CRS score: 13-16).
- WL5 (Extreme level) - System is not wearable, extremely stressful, and potentially harmful (CRS score: 17-20).

B. Flow of the User Study

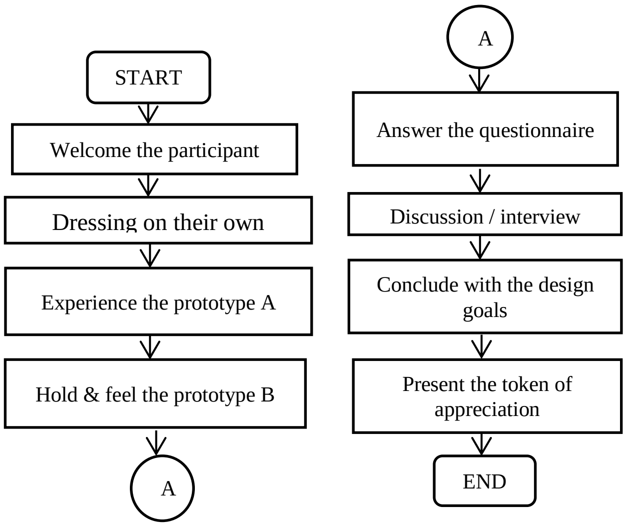

Figure 6. The user study flow.

Including the users during the early discussion and design stages is beneficial to facilitate in generating the new design concepts or iterations [21]. Based on the comprehensive review of the methodology to conduct the user evaluation study for certain product, we designed a preliminary study to evaluate the wearability of Cliff. Shown in Fig. 6 is the flow for the study. The session will start with welcoming the elderly, a short ice-breaking and briefing about the procedure of the experiment. If the participant agrees to all the conditions, they will put their signature on the consent form. Then, the elderly will be asked to dress and undress themselves using two garments with a zipper (preferably jackets) that they bring on their own. The seniors then will experience the protoype A (Fig. 4) of this project which Cliff will automatically do the zipping and unzipping process on the jacket designed by Marina Toeters. After that, they will be given prototype B (Fig. 5), which is a complete unit prototype. They will grab, hold and feel the prototype on their hands and jacket while sitting, standing or walking with it. In the following step, the elderly will be given a questionnaire to be filled in about the wearability assessment. After they finished answering the survey, a short interview and discussion session will be conducted to ask for their opinion about Cliff on certain aspects such as the function and additional features of it. At the end of the interview session, the moderator will explain the design goals of this project. Lastly, a token of appreciation will be presented to the elderly. Then, the moderator will guide the elderly to the exit door. The whole session will approximately take about 37 minutes per participant.

C. Participants

There were 22 volunteered participants involved in the preliminary user study. Eight of the participants were male elderly while the rest were female. The youngest participant is 60 years old, while the oldest is 86 years old (Mean: 72.3, SD: 7.9). Nine of them are in the age bracket of 60-69 years old, eight are 70-79 years old, and the rest are 80-89 years old. All of them are the Dutch people living in the city of Eindhoven, Wagenigen, Rotterdam and, Den Ham. They were randomly recruited. The session was conducted at the elderly place. Shown in Fig. 7 are the few pictures taken during the user study session. As seen in the figure, the seniors were given a chance to experience the Cliff prototype and get a close view of it. The prototype worked very well during the session, and the elderly enjoyed seeing the movement of Cliff on the jacket.

Figure 7. Pictures taken during the user study session.

IV. RESULTS

A. Quantitative Results

The average results of general comfort using the comfort rating scales (CRS) for Cliff are shown in Fig. 8. The reliability testing is performed to assess the internal consistency of the questionnaire used. The Cronbach's alpha value for the data recorded is 0.713. Thus, it shows a satisfactory requirement of reliability based on the Cronbach's alpha value obtained being more than 0.7 [22–24]. There were considerable ranges of responses for each of the comfort dimensions (abbreviations: M=mean, SD=standard deviation). The highest average CRS score was for the Perceived Change dimension (Median=7.5; M=6.8, SD=4.3). Meanwhile, the lowest CRS score was recorded for the Harm (Median=1.5; M=1.9, SD=2.4) and Movement (Median=1.0; M=2.6, SD=4.3). The CRS score for the Attachment (Median=5.2; M=6.4, SD=4.5), Emotion dimension (Median=4.8; M=6.0, SD=5.0), while the Anxiety (Median=5.0; M=5.0, SD=3.6). From the box plot, it can be seen that the box plot for the Emotion, Attachment, Perceived Change and, Anxiety dimensions are comparatively tall, which suggests that the elderly hold quite different opinions about these dimensions. However, the box plot for the other two dimensions

(Harm and Movement) are comparatively short which indicate that the participants have a high level of agreement with each other on these dimensions. The following graphs will discuss in detail the responses received for every question in each of the comfort dimension.

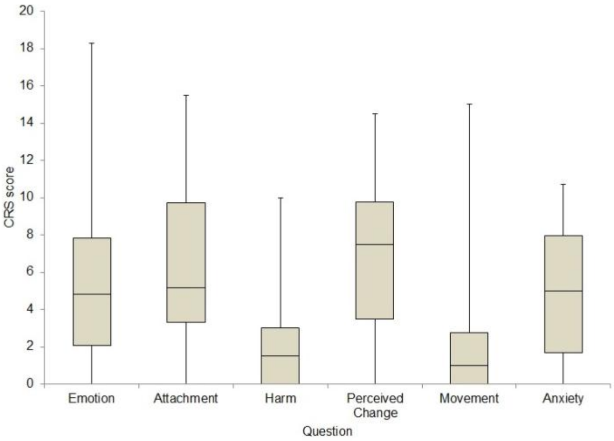

Figure 8. The overall CRS score for the general comfort of wearable system.

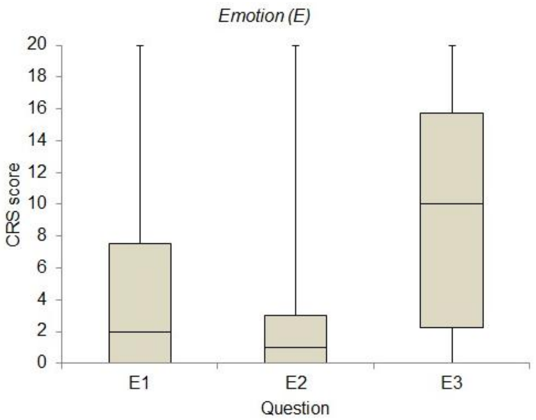

Figure 9. The CRS score for each question in the emotion dimension.

Fig. 9 shows the CRS score of the response received from the participants for each question in the questionnaire related to the Emotion dimension. The Emotion dimension concerns the appearance and relaxation of the device. The first two questions E1 (I feel worried and embarrassed) and E2 (I feel tense) in this comfort dimension try to evaluate whether the elderly feel afraid, ashamed or nervous while using Cliff. Meanwhile, the third question E3 (I would wear the device if it was invisible), assesses whether the invisibility of the device could affect their decision to wear it. Fig. 9 describes that the elderly did not feel worried, embarrassed or tense while using Cliff since the CRS score of E1 (Median=2.0; M=4.5, SD=5.7) and E2 (Median=1.0; M=3.5, SD=5.6) fall in the Moderate level and below. 75% of the elderly mark the score below 5 for E1 (moderate level) and below 3 (low level) for E2. During the user study, most of the elderly enjoy and excited given the opportunity to experience the prototype. They thought that the device was a little funny when they saw it move on the jacket and when they heard the sound of the device during its operation. However, their interpretation of the visibility of Cliff on the jacket is different (question E3). They tend to rate the comfort level from Large to Extreme level as they agree with the statement that they would wear the device if it is invisible (Median=10.0; M=10.0, SD=7.1). It might be related to their appearance while wearing Cliff itself.

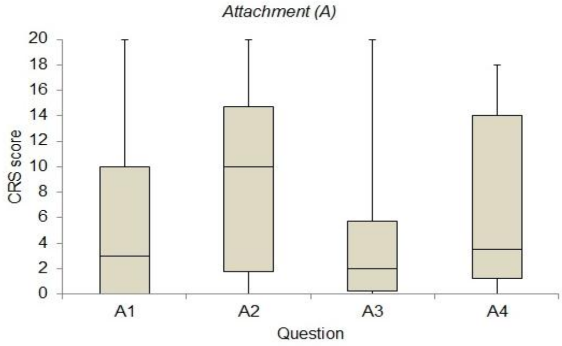

Figure 10. The CRS score for each question in the attachment dimension.

Fig. 10 illustrates the responses received for four questions (A1 to A4) related to the Attachment dimension. This dimension tries to evaluate the physical feel of the device on the body. From the graph, we can see that the elderly did not really feel the device on their body based on the CRS score for question A1 (Median=3.0; M=6.0, SD=6.8). However, they can feel that the device is moving based on the responses for question A2 (I feel the device moving), which over half of the participants rated the CRS score over 10 (Median=10.0; M=9.0, SD=6.5). Moreover, the elderly think that Cliff did not pose any difficulties to move as usual based on the CRS score on the question A3 (Median=2.0; M=4.0, SD=5.1). The box plot for A3 is comparatively short which describe a high level of agreement among the elderly that Cliff did not obstruct them to move as usual. Meanwhile, the elderly have different views about the difficulty to put on Cliff since the box plot of A4 (I have difficulty in putting on the device) is comparatively tall. However, 50% of them mark the score below 3.5 (Low level) with the average score of 6.4 and standard deviation of 6.8.

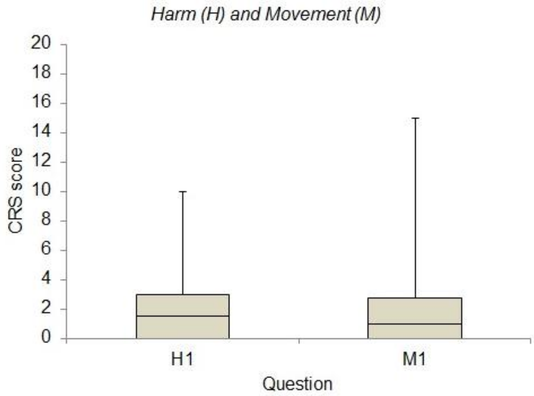

Figure 11. The CRS score for each question in the harm (H) and movement (M) dimension.

Fig. 11 shows the results for comfort dimension of Harm and Movement. The Harm dimension is described as the physical effect or damage to the body, while Movement evaluates the device physically affects movement. As can be seen in Fig. 10, the participants highly agreed that Cliff did not cause any harm and did not obstruct their movements. The results are in line with their responses towards question H1 (The attached device caused me some kind of harm) and M1 (The device obstructs my movements). Both box plots are comparatively short based on the CRS score recorded for H1 (Median=1.5; M=1.9, SD=2.4) and M1 (Median=1.0; M=2.6, SD=4.3). Both scores represent the Low level. However, when they try to walk with the device on the jacket, a few of the elderly feel that the device is quite heavy for such a light fabric, but it still does not affect their daily movements.

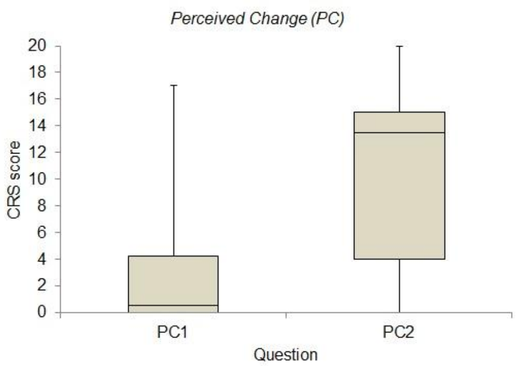

Figure 12. The CRS score for each question in the perceived change dimension.

The perceived change dimension evaluates the feeling physically different or upset. The given questions of PC1 (I feel more bulky) and PC2 (I feel the change in the way people look at me) try to investigate whether the user is feeling bulkier wearing the wearable device and is the user feel the change in the way people look at them. As depicted in Fig. 12, it can be seen that the elderly did not feel bulkier while wearing Cliff on the jacket based on the response to question PC1 (Median=0.5; M=3.4, SD=5.6). The box plot for PC1 describes that 75% of the participants mark the score as below 3 (Low level). However, from the interview, most of the participants stated that Cliff's size is still too big and they wish to have a smaller one in the future. Putting Cliff on the jacket and looking or grabbing the prototype itself gives a different indication of the way they think about its size. From Fig. 12, half of the elderly provide ratings of Very Large to Extreme level for the second question (PC2) regarding whether they feel any changes in the way people look at them while wearing the device. The median score for PC2 is 13.5 with a mean of 10.2 and standard deviation of 6.6. During the interviews, the elderly mentioned that they would feel different because they are dressed in a device which is not carried by the others. Besides that, they also told us that people would think "what is wrong with this person" if they are wearing Cliff and carry it everywhere. However, the elderly said that if the device is removable and can be kept somewhere in one's pocket for instance, it would be okay for them. The box plot is also comparatively tall which suggests that the elderly hold quite different judgments about how other people see them while wearing Cliff.

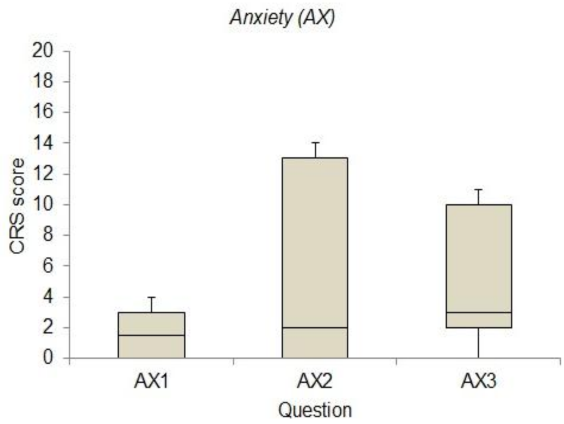

Figure 13. The CRS score for each question in the anxiety dimension.

The final comfort dimension in this study is Anxiety. It describes the worry about the device, the safety and reliability. Fig. 13 depicts that the elderly do feel secure with Cliff based on the CRS score of question AX1 (Median=1.5; M=2.8, SD=4.4). Meanwhile, 50% of the participants think that the device is properly attached to the jacket (Median=2.0; M=5.6, SD=6.7) based on the response towards the question AX2. However, the other half have different opinions about how Cliff is attached to the jacket since some of the elderly marked a high score up to 14. Meanwhile, the elderly agreed that Cliff works correctly during the test as they can see the device completing the zipping and unzipping process automatically based on their answer for question AX3 (I feel that the device is not working properly). However, from the interviews, some participants mention that they would not wear the device if it is not properly integrated (the wire, battery, switch). They told us that a much proper integrated design is necessary to ensure the safety of this device.

B. Qualitative Results

The interview session tries to dig deeper into the problems or difficulties when the elderly use the zipper, their first impression and, their feeling while walking or sitting with it. This session also aims to know the additional features that they wish to included in Cliff, and any other suggestions to improve the design itself.

The common problems that most of the participants faced while using the zipper are when the fabric gets stuck in the zipper element and joining the bottom pin. Moreover, the elderly told us that when they stand, it is not easy to join the bottom pin. One of the participants mentioned that she decided to not close the jacket zipper because she found it hard. Another elderly female told us that she feels embarrassed when others look at her when she is hassling with her zipper. She then leaves the jacket open and closes it when sitting out of sight, like in her car.

Their first impression and feelings about Cliff are more on seeing this as an unknown electronic device. They seem very excited to know what this device can do and assist them. They see this as a potential device for the elderly, people with physical disabilities and, wearing dresses with back-zippers. The comments are mainly focused on the size of Cliff, which they think is too big and bulky.

When asked about their feelings while walking or sitting with the device, they find that it is a little strange since they are wearing a device that other people do not wear. For them, it will lead others to question what is wrong with this person. This is related to the stigmatisation effect. To overcome this problem, a few participants told us that it would be okay if the device is removable. Other than that, most of the elderly feel funny from their experience with Cliff. For them, it is quite comfortable to have it on the jacket. However, they think that Cliff is quite heavy for such a light fabric.

Discussing the additional features that they wish included on Cliff, they mainly requested a proper switch or button to operate the device on the jacket, next to the zipper tape, or introducing a wireless switch. They also suggested having it in different colours and with controllable speed. Having a temperature sensor and alarm clock to remind them to takes their medicine are also few of the suggestions raised by the elderly. Overall, they want Cliff to be compact in size, fully integrated and, light in weight.

V. Discussion

A. Concerning the Design Process

Overall, as designers, going through the iterative research through design and the user study during the early development stage of Cliff is a great experience. Besides that, to successfully develop a correct mechanism for the robotic zipper, it is a must to first understand the physics and mechanics of the conventional zipper as explained in [14]. The use of kinematics analysis is also essential to help us examine the forces acting on the system and calculate the amount of torque and power required to drive the miniature model of Cliff [14]. This interaction and input are effective during the period to maximise the efficiency of prototype design development. Furthermore, it could drive the design projects towards capturing the finalised design solution. It creates a cycle that you can't wait to start redesign again, analysing and testing the new design based on the feedback received from the users. The motivation to design again is proof that as a designer, this methodology is a useful tool to assist in creating a better design. Adopting the user study approach has the potential to improve the current design towards a better one. The input, feedbacks, and comments received from this study will be used for the next design iteration of the automatized zipper.

B. Product Semiotics, Stigmatisation Effect and, Personalisation

Most participants' first impression of Cliff is that they see an unknown electronic device. They don't have an idea what this product can do or how they should use it. This remark shows how essential the aesthetic value is in design. The look of the wearable itself plays an important role to ensure that the user could positively perceive the device. The semiotics of fashion are an important part that need to be considered in the next development cycle of the automatized zipper. It is crucial to understand how humans signify particular social and cultural positions through garments. For instance, the shape of Cliff will carry a meaning, creating a first impression of the user and people who are looking at it for the first time. The current presentation with visible – not fully covered – electronic components, quite boxy and, lack of style is not useful to produce a positive perception of the user. The current appearance of Cliff does not relate to the zippers. It might be a potential solution to reduce the stigmatisation effect. The new look should be more informed by society and fashion. Therefore, the following design iteration will review the shape and looks of Cliff.

Stigmatisation among the elderly is one of the issues that captured our attention from the user study. It relates to the social wearability aspect where Cliff could be abandoned like other fully functional or high-performing devices if the importance of the aesthetic value is neglected [25]. The comfort dimension of perceived change alerts us with a high level of participant response. Vaes defined stigma as "a mark that links someone to undesirable characteristics" [26]. Functional ability often decreases in such a slow and incremental manner that it is not noticeable in everyday life. It can result in the elderly's perceived ability remaining at a much higher level than their actual ability. This overconfidence in one's abilities may cause an elder to refuse to adopt devices that could be helpful for them [27]. Perception had a strong influence on adoption. Devices that cause users to feel ashamed and powerless are said to possess a stigmatising aesthetic and may contribute to late-life depression.

Vaes *et. al.* also think that personalisation could reduce the stigma. Personalisation will enable the user to make their choice in a product to match and suit their identity. This is in line with few requests received from the participants who would like to have Cliff in a variety of colours to match the garments they are wearing. Empowering the user could also overcome the stigma [26, 27]. Empowering the products should deliver intrinsic value and meaning for that person and make a product user feel stronger and more capable. Making it easy to be used for individuals with a broad range of cognitive and physical abilities is one of the important factors that should be in the designer's mind. The widespread use will help reduce the social stigma often associated with any assistive devices [27]. Taking this factor into consideration in the design will ultimately reduce the social and economic barriers to adoption and furthers the cause of universal usability.

VI. Conclusion

Lessons learned: Throughout the early development stage of this project, we have performed a few design iterations to create a working prototype of the automatized zipper. The research through design practice has been applied along this process. Furthermore, a wearability assessment on the general comfort of Cliff: an automatized zipper has been conducted. Based on the quantitative results it can be concluded that the acceptance of the automatized zipper is satisfactory with all the levels of effect on each comfort dimension scoring at the Low and Moderate levels. It can be concluded that Cliff achieve the second wearability levels, WL2 which means that the system is wearable, but changes may be necessary, and further investigation needed. Therefore, there are some important issues concerning of the product itself to be considered in the next design iteration, such as the stigmatisation and product semiotics. Improving the aesthetic aspects of Cliff is essential to reduce the stigma effect, thus possibly generating positive perception and influencing the users to adopt this device. The product form is crucial to produce an excellent communication of the product and its potential market.

Future work: The next design iteration will focus on improving the semiotics of Cliff, reducing the stigma and empowering the device. The size and presentation of Cliff which is quite bulky and not stylish will be revised to ensure positive perception from the user and diminished the stigma. The existing meaning of Cliff will also need to be improved by empowering the user and the product itself. Finding the correct application, function, and presentation for this automatized zipper is vital towards the universal usability and to ensure that the users will positively perceive this device.

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