Wearability and Usability Assessment of Cliff: An Automatized Zipper

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***Abstract*—Being independent to dress or undress is important for everybody. However, (un)zipping to (un)dress is a task that is difficult for elders, especially when the zipper is in a hard-to-reach location. This paper presents the invention of Cliff: an automatized zipper and a user study performed to evaluate the wearability and how useful it is to the elderly. Results of the user study show that the elderly rated Cliff as wearable, useful, and makes the zipping and unzipping task much easier for them. This prototype system and the feedback received from the elderly contribute to the design of fashionable automated assistive technologies.**

***Index Terms*—automatized zipper, user acceptance, elderly**

I. INTRODUCTION

A zipper is a simple device which is commonly used to join two pieces of fabric or flexible material together. For instance, on the garments such as on the jackets and dresses. Although it is easy to operate the zipper, not everybody can perform the zipping or unzipping task independently.

Independence to dress or undress is essential for everybody since it is one of the basic everyday tasks in the activities of daily living (ADLs). It describes whether a person is capable of living independently, requiring assistance or dependent. However, (un)zipping to (un)dress is a difficult task for the elderly, especially when the zipper is located at the back and difficult to reach. Gradual worsening of vision of the elderly will make it harder for them to operate the zipper. These people who are unable to zip or unzip themselves will require assistance from others to perform the task.

Therefore, we present Cliff (Fig. 1), an automatized zipper. Cliff is aimed to ease the zipping and unzipping process. It could reduce the difficulty of the elderly and ladies who have problems zipping a back-zipper dress.

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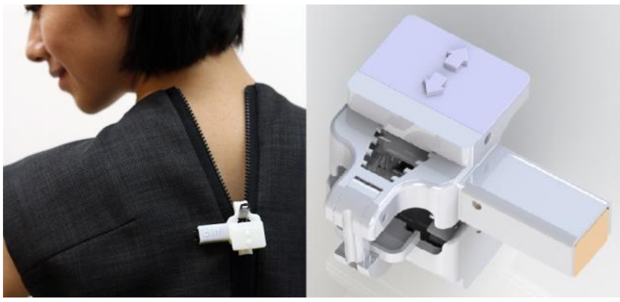

Figure 1. (a) A model wearing Cliff on her jacket, (b) 3D view of Cliff prototype.

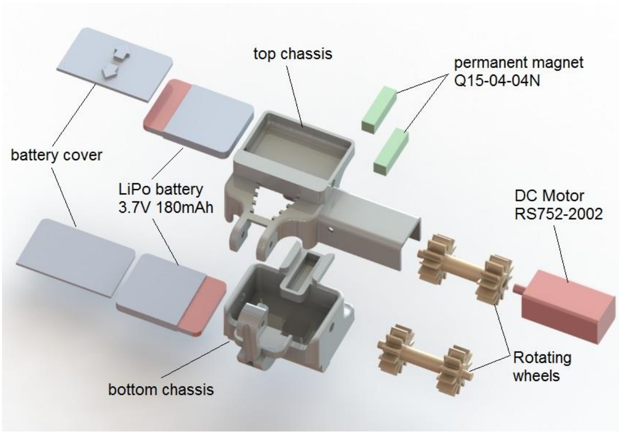

Figure 2. The overview of cliff components.

This project was inspired by Adam Whiton, who build the Zipperbot [1]. Adam's Zipperbot did not use the slider of the zipper to zip or unzip, which makes it a nongeneric system and every garment needs its own Zipperbot. Our Cliff retains the original zipper's structure and offers a generic and universal type of robotic zipper. Fig. 2 shows the exploded view of the Cliff components. Each prototype consists of a top chassis, a bottom chassis and, two rotating wheels which were 3D printed. A 6V DC motor with a speed of 145 rpm and 68mNm torque is used to drive Cliff based on the kinematic analysis performed by Baharom *et al*. [2]. The prototype is powered by the two LiPo batteries (3.7V, 180mAh) and is controlled using a toggle switch. Two neodymium

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(NdFeB) magnets with a pull strength of 1.7 kg are used to provide sufficient normal force to clamp the top and bottom chassis. Fig. 3 shows the traction mechanism of Cliff which used two gear sprockets on both sides of the tape to establish the uniform distribution of normal force acting upon the zipper tape. The gear teeth grabs the zipper tape.

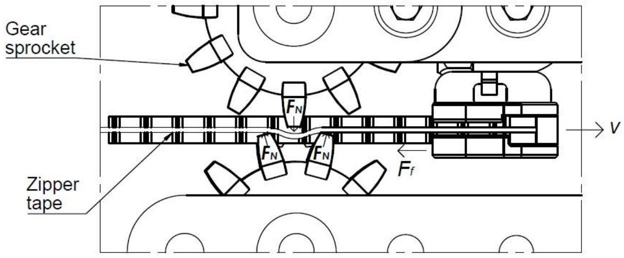

Figure 3. Cliff traction mechanism *(F_N = normal force, F_f = friction force, V = velocity)* [2]

A user study was structured to evaluate Cliff with 72 participants (elderly). The study measures the wearability assessment (WA) [3]-[5] on general comfort towards the automatized zipper, perceived usefulness and perceived ease of use (PEoU) [6], and the credibility and expectancy (CE) [7]. Based on the quantitative results, the acceptance of Cliff prototype is satisfactory, and the system is wearable. However, a few changes may be necessary, and further investigation needed. The findings also identified that the elderly agreed that Cliff would bring more quality to perform the zipping and unzipping task. They believed that the automatized zipper is a practical and useful device to assist them in using the zipper. Regarding the perceived ease of use, the participants found that Cliff is easy to learn, controllable, and understandable. The more comfortable a technology to be used, the more useful it can be [8]. The function offered by Cliff is slightly logical for them, and they are confident in recommending the device to other people who have difficulty with the zipper.

The main contributions of this work are 1) a physical design of a generic automatized zipper to ease the zipping and unzipping task, and 2) user experiences and experimental results regarding the wearability, usability, ease of use, and the credibility/expectancy of the automatized zipper. We have chosen to measure these aspects of the user experience (rather than pure functional performance or aesthetics) because the design is still a compromise between conflicting requirements. It is a bit bulky issues such as fear for stigmatisation could still block adoption. The chosen measures mediate between function and adoption.

II. Related Work

Eddie Howe invented the first zipper about 166 years ago [9]. Since then,there has been a continuous further development of the slider. A visualisation of the evolution is based on our own review of the patents on zippers. The slider is considered as the engine of the zipper's system. For the past 166 years, the design of the zipper's slider has evolved from the conventional type to the removable, rollable, adjustable and currently, the designers and inventors are moving towards developing an automatic or robotic zipper. Fig. 4 visualizes the design evolution of the slider based on the patent review performed.

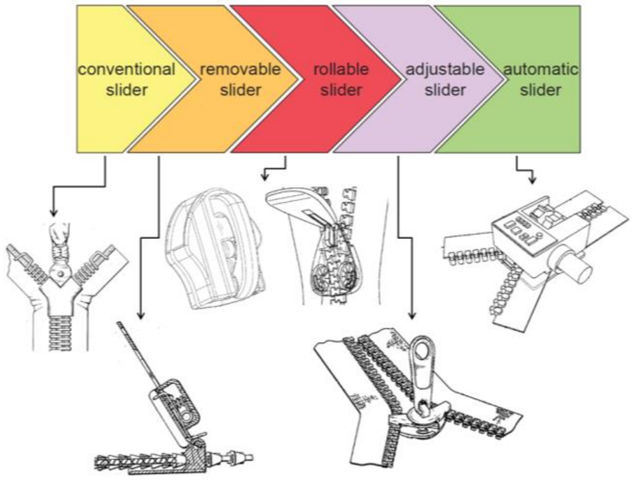

Figure 4. Zipper's slider evolution [1], [10]-[13].

After the invention of the conventional slider in 1851, Mucci invented a removable slider in 1938 [10]. Nissen then patented a reversible slider about twelve years later [14]. Both designs triggered the beginning of making a flexible or removable slider. In 2013, Wang patented a roller zipper slide which employed a rolling contact technique to replace the conventional surface friction designs [12]. In the same year, a wheeled slider was patented by the UNDER ARMOUR company [15]. The wheeled slider design has two wheels slided on the side of the element. However, from the construction of the wheeled slider, it is only suitable for a zipper with a flat side surface of the plastic elements, and not ideal for the coil zipper. A year later, the Genmore Zipper Corporation from New Taipei patented a roller-loaded slider design [13]. The design comprises at least one roller bracket each carrying a front roller. Three years later, an adjustable slider was invented by Alberto from Argentina [16]. The adjustable slider can be pivotally opened and closed horizontally, and it can be locked in the appropriate size of the zipper. In 2017, Adam Whiton patented his robotic zipper known as Zipperbot [1].

Moreover, there are research projects related to the development of the vertical climbing robot (climbing on the garments). The projects identified are the Clash [17], Clothbot [18], Rubbot [19] and, the Rovables [20]. These projects are focusing on developing the vertical climbing robot, and each of it came with a different kind of traction mechanism. The researchers mostly discussed the construction and the technical part of the vertical climbing robot design and developments. However, none of these inventions has been tested with the user. The design evolution of the zipper's slider and the progress of the vertical climbing robot developments prove the existence of some efforts in designing a new kind of the zipper or a wearable that could climb on the garments. Thus, it is aligned with our intention to design and develop Cliff as an automatized zipper.

III. User Evaluation

A. User Study Flow

Fig. 5 shows the flow of the user study which was performed to evaluate the user experiences of Cliff. Upon arrival, the participants were explained about the procedure of the experiment and were asked to sign the informed consent form. The moderator explicitly explained the overall of Cliff idea. Then, the elderly were asked to dress and undress the jacket with the regular zipper on their own. The participants were then given Cliff prototype (Fig. 1(b)) to automatically do the zipping and unzipping process. The elderly could also have a close look at the prototype. In the following step, the participants were required to answer a set of questionnaires regarding the wearability, perceived usefulness, perceived ease of use and, credibility and expectancy assessment. Then, an interview was conducted to gain the feedback about Cliff. Lastly, the moderator briefly explained the design goals of this project. The whole session took about an hour per participant.

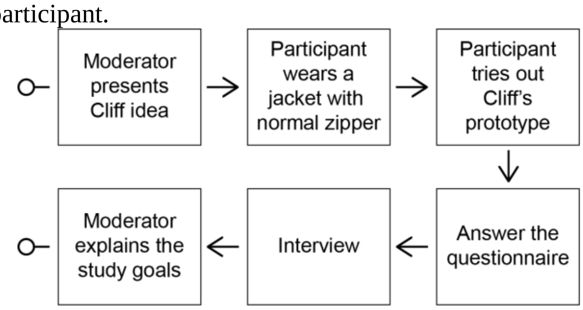

Figure 5. The flow of the user study.

B. Participants

Seventy two volunteer participants (24 male and 48 female) aged between 60 to 78 years old (Mean = 65.6, SD = 4.4) took part in this study. Based on the sample power calculation using the G*Power software which used the study performed by Baharom et al. (in total of 22 participants), it was found that less than 10 participants is enough to achieve a statistical significance score of at least 0.8 [21]-[23]. However, for this study, the aim is to get as many participants as possible to gain more feedback and input from the users. The participants were recruited by six elderly activity centres.

C. Ethics Approval

The research was approved by The Research and Co-ordination Committee, Economic Planning Unit, Prime Minister's Department of Malaysia (approval letter: UPE40/200/19/3502), and the Department of Social Welfare, Ministry of Women, Family, and Community Development, Malaysia (approval letter: JKMM 100/12/5/2:2017/475).

D. Data Collection and Analysis

Four sets of data were measured within this experiment, (1) Wearability Assessment (WA), (2) Perceived Usefulness (PU), (3) Perceived Ease of Use (PEoU) and, (4) Credibility and Expectancy (CE).

TABLE I. General Description of Each General Comfort Dimension

Dimension	Endpoint	Description
Emotion	Low	I am not worried about how I look when I wear this device.
	High	I 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.

Wearability assessment (WA). 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 [4]. Knight et al. presents a tool (Comfort Rating Scales (CRS)) that measures wearable comfort across six dimensions which are the emotion, attachment, harm, movement, perceived change and, anxiety. Table I describes each general comfort dimension of the comfort rating scales (CRS). The CRS used a 21-point scales anchored at each end with the labels 'low' and 'high' (low (0-4), Moderate (5-8), Large (9-12), Very Large (13-16) and, Extreme (17-20)). 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 given.

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, fiveWearability Levels (WL) can be suggested which are [24]:

1) WL1 (Low level) - System is wearable (CRS score: 0-4).
2) WL2 (Moderate level) - System is wearable, but changes may be necessary, further investigation needed (CRS score: 5-8).
3) WL3 (Large level) - System is wearable, but changes are advised, uncomfortable (CRS score: 9-12).
4) WL4 (Very Large level) - System is not wearable, fatiguing, very uncomfortable (CRS score: 13-16).

5) WL5 (Extreme level) - System is not wearable, extremely stressful, and potentially harmful (CRS score: 17-20).

This tool has been tested to examine the wearability of four different kinds of wearable; 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 [4]. The CRS method also has been applied by Sotiriou *et al*. to assess the wearability of the CONNECT mobile Augmented Reality (AR) system [25]. Besides that, Weller et al. used the CRS evaluate awearable computer system designed at the intensive care unit (ICU) of a hospital [26].

Perceived usefulness (PU). Perceived usefulness is defined by Davis et al. as "the degree to which a person believes that using a particular system would enhance his or her job performance" [6]. It is a continuation of the definition of the word "useful" which means as "capable of being used advantageously". The perceived usefulness evaluation is performed to assess whether the elderly believe or not that Cliff can perform the zipping and unzipping task better. The questionnaire used the Likert scale (1-7) with the strongly agreed and strongly disagreed located at the end of the lowest (1) and highest (7) score. For the questionnaire, the lower the score is the better. The six questions on the PU examine whether the work performed by the new system is more in quality, improve the job performance, increase the productivity, effectiveness, makes the job easier and, useful or not.

Perceived ease of use (PEoU). In contrast, the perceived ease of use refers to "the degree to which a person believes that using a particular system would be free of effort" [6]. It is a continuation of the definition of the word "ease" which means the "freedom from difficulty or great effort". Even if the elderly believe that Cliff is a useful device, they may, at the same time feel that the automatized zipper is too hard to be used. The performance benefits of usage are outweighed by the effort to use the device itself. The questionnaire given is also used the Likert scale (1-7) with the strongly agreed and strongly disagreed located at the end of the lowest (1) and highest (7) score. For the questionnaire, the lower the score is, the better. The six questions on the PEoU evaluate whether Cliff is easy to learn, controllable, understandable, flexible, easy to become skilful, and easy to be used.

Credibility and expectancy (CE). The term credibility is defined as "how believable, convincing, and logical the system is" whereas expectancy refers to "improvements that clients believe will be achieved" [7]. It relates to the term "believe", which contains both cognitive and affective components. What the elderly think about Cliff may differ from what they felt to it. For the study, the participants will answer two sections which are related to thinking and feeling. The Likert scale anchored from score 1 to 9. The lowest score (1) indicates strongly disagreed while the highest score (9) is strongly agreed. Therefore, the higher the score is, the better.

Quantitative Data Analysis. The normality test is performed using the Kolmogorov-Smirnov test (N>50) [27]. The sample power for each questionnaire has been calculated to assure an adequate power to detect the statistical significance [23]. The G*Power software was used to calculate the statistical power while the other statistical analyses were performed using the IBM SPSS version 23.0 [22], [25]. Meanwhile, the internal consistency of all the four questionnaires was assessed by the Cronbach's alpha coefficients [6], [28], [29]. The data was analyzed with the median scores (MED) and the interquartile range (IQR) [3], [4], [28]. The one sample Wilcoxon signed-rank test (WSRT) was used to evaluate differences with the neutral point of the scale (marked in red line in the box plot). For the WA, PU, and PEoU data, the median value of each scale is considered as the neutral score. The scores lower than neutral are positive, and scores higher than neutral are negative. However, for the CE questionnaire, the median value is considered neutral, scores higher than neutral are positive, and scores lower than neutral are negative.

IV. Results

A. Data Reliability, Normality, and the Sample Power

Table II summarizes the results of the reliability test (Cronbach's aplha), normality test (Kolmogorov-Smirnov), and the sample power calculation (G*Power). It can be seen that the Cronbach's alpha for all the four set of questionnaires are more than 0.7 which described a satisfactory requirement of reliability for the research instruments [4], [6], [28]. The Kolmogorv-Smirnov test indicated that WA, PU, PEoU, and CE ratings were not normally distributed ($p<0.05$). Therefore, one sample Wilcoxon signed-rank test (WSRT) was performed. Meanwhile, the sample power calculated using the G*Power software were found to be higher than 0.9. The value indicated that the sample size used for the study is adequate to detect statistical significance (sample power > 0.8) [23].

TABLE II. The Summary of the Reliability Test, Normality Test, and the Sample Power

Evaluation	Reliability test (Cronbach's alpha)	Normality test (p-value)	Sample power
Wearability Assessment (WA) (N = 14)	0.861	0.001	0.947
Perceived Usefulness (PU) (N = 6)	0.913	0.001	1.000
Perceived Ease of Use (PEoU) (N =6)	0.814	0.001	1.000
Credibility and Expectancy (CE) (N = 4)	0.816	0.001	1.000

B. Wearability Assessment

Table III presents the overview of the Median, IQR score, and one sample WSRT result for each of the comfort dimensions. Fig. 6 summarizes the boxplot for the average score of each comfort dimension. A few researchers used the average CRS score to discuss the overall result of the assessment [3], [4], [28]. It can be seen from Fig. 6 that the attachment dimension scored the highest CRS score (MED = 9.5, IQR = 5.1, p = 0.030*). This is perhaps not surprising, as it can be expected that the participants would feel the device on the body and it is highly noticeable while it moves to open or close the zipper. The high score may not necessarily mean that the system is not wearable. These conditions indicated that the elderly can feel the device on their body and it is highly noticeable [24]. It is obvious to have these kind of results since Cliff is a kind of wearable which is attached to the jacket and it moves to automatically open and close the zipper. The results also suggest that the elderly are positively agreed that they are able to move as usual while wearing Cliff. However, if the aim to develop this kind of device to be likened to items of clothing, then it should feel like clothing [4]. It is important to ensure that the users are hardly notice the physical sensation of wearing the device just as how they wear the everyday clothing items such as the jewelry or spectacles.

TABLE III. Overview of the Wearability Assessment Scores

Factor	Median (IQR)	WSRT
Emotion	6.7 (10.0)	z = -3.982, r = 0.469, p = 0.001**
Attachment	9.5 (5.1)	z = -2.164, r = 0.255, p = 0.030*
Harm	2.0 (3.7)	z = -6.797, r = 0.802, p = 0.001**
Movement	2.0 (4.0)	z = -6.106 , r = 0.720, p = 0.001**
Perceived change	8.2 (9.0)	z = -3.869, r = 0.456, p = 0.001**
Anxiety	2.8 (5.7)	z = -6.501, r = 0.767, p = 0.001**

**Indicates highly significant, p < 0.01, *Indicates significant, p < 0.05, r > 0.5 indicates large effect size.

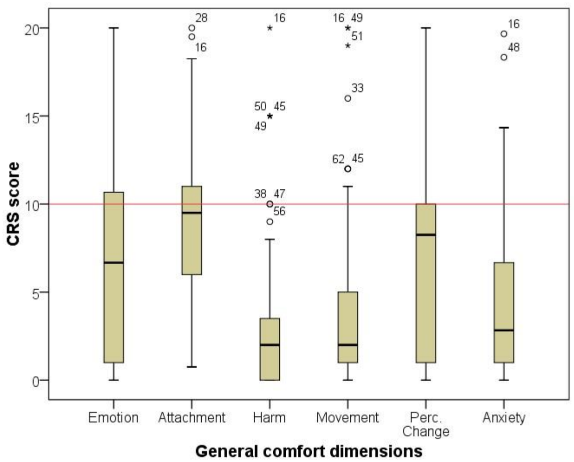

Figure 6. The boxplot for the average score of each comfort dimension

The perceived change dimension recorded the second highest CRS score (MED = 8.2, IQR = 9.0, p = 0.001**). The participants might have different views on the two questions given whether they feel bulkier and do they feel change on the way people looking at them based on the high score of the IQR (9.0). From the interview, most of the participants agreed that Cliff is still big in size. However, they do not care about what other people think about them while wearing the device, as long as it is beneficial for them. However, some of the elderly think the other way and rated a higher score.

Meanwhile, the emotion dimension score suggests that the users are not embarrassed to wear Cliff (MED = 6.7, IQR = 10.0, p = 0.001**). The participants are not feeling worried, embarrassed or, tense with Cliff. Moreover, the participants indicated that they would wear Cliff if it is invisible. Making the automatized zipper less conspicuous could improve the score. It involves reducing the size of Cliff or obscuring it from view by hiding it somewhere else. The elderly agreed that the idea of making Cliff a removable piece is good so that they can remove it from the zipper and keep it in the pocket for instance. If more people use the device as an everyday item of clothing, it can also reduce the embarrassment factor [4].

The harm, movement, and anxiety obtained low scores. It describes that Cliff is not painful or harmful to wear (MED = 2.0, IQR = 3.7, p = 0.001**), did not obstruct the user movement (MED = 2.0, IQR = 4.0, p = 0.001**), and they are not feeling worried to use the automatized zipper (MED = 2.8, IQR = 5.7, p = 0.001**). The participants are strongly agreed that Cliff did not causing any harm or obstruct their movements since the boxplot for both harm and movement dimensions are comparatively short. For the anxiety dimension, the overall score recorded suggests a high agreement among the participants that they are not worried to use Cliff. They also found that Cliff is properly attached to the jacket and it is working properly during the user study.

Therefore, from the results of the six comfort dimensions measured, it can be concluded that Cliff achieved the second wearability levels, WL2. It means that the system is wearable but changes may be necessary and, further investigation is needed [4], [6], [24]. Since the CRS scored high for the attachment and perceived change dimensions, it suggests that focus should be placed on the physical factors. For instance, the weight, the size, weight distribution and, how to attach Cliff to the users.

C. *Perceived Usefulness and Perceived Ease of Use*

Table IV summarizes the Median, IQR scores, and one sample WSRT results for the perceived usefulness and the perceived ease of use. Both factors which are the perceived usefulness (MED = 1.8, IQR = 0.7, p = 0.001**) and the perceived ease of use (MED = 2.0, IQR = 0.8, p = 0.001**) recorded the low scores. Fig. 7 shows the boxplot of the perceived usefulness and the perceived ease of use score. The low scores recorded explain a positive response. The result shows the elderly rated positively that Cliff will bring more quality for the zipping and unzipping task, improve the job performance, and increase their productivity.

Moreover, it also explains that the participants are strongly agreed that Cliff is effective, useful, and makes the zipping and unzipping task much easier for them. Meanwhile, the boxplot of the perceived of use explains that the elderly acknowledged Cliff as easy to learn, controllable and understandable. They believed that Cliff is flexible because it can be removed from the garments. For them, it is not too difficult to operate Cliff but they still need to learn on how to attach the zipper's pull tab to Cliff. However, the elderly believes that with increasing experience using Cliff, the system may become more routinized and less challenging for them to use it. It is expected that with the increasing experience with any devices, the user will adjust their perceived ease of use of the system [8].

TABLE IV. OVERVIEW OF THE PERCEIVED USEFULNESS AND PERCEIVED EASE OF USE SCORES

Factor	Median (IQR)	WSRT
Perceived usefulness	1.8 (0.7)	z = -6.960, r = 0.821, p = 0.001**
Perceived ease of use	2.0 (0.8)	z = -7.371, r = 0.869, p = 0.001**

**Indicates highly significant, p < 0.01, *Indicates significant, p < 0.05,
r > 0.5 indicates large effect size.

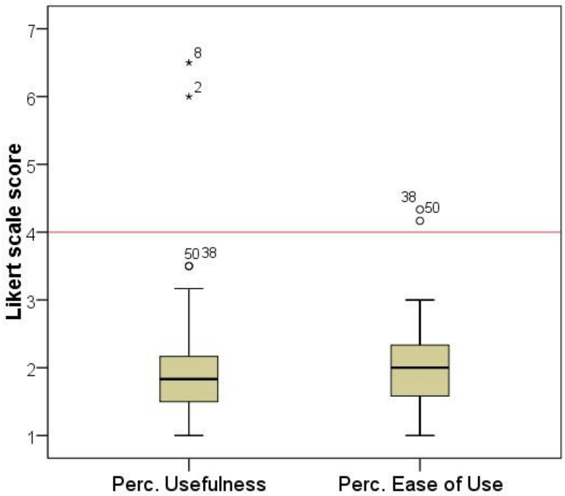

Figure 7. The boxplot for the perceived usefulness and the perceived ease of use

D. Credibility and Expectancy

Table V presents the overview of the Median, IQR scores, and one sample WSRT results for the credibility and expectancy factor. From the overall results, all the subscales for the credibility and expectancy are highly significant (p < 0.01). Fig. 8 shows the boxplot of both factors assessed. The credibility factor obtained moderate score (MED = 6.3, IQR =2.7, p = 0.001) while the expectancy achieved high score (MED = 8.0, IQR = 3.8, p = 0.001). The scores indicated that the function offered by Cliff is slightly logical and useful for the elderly. This is an excellent score where most of the participants feel that the invention of Cliff could reduce their difficulty on using the conventional zipper. Meanwhile, the participants rated higher than the neutral score on how they think and feel about the improvement brings by Cliff to their problem while using the zipper. The elderly are also confident in recommending the automatized zipper to their friends who have difficulty with the zipper.

TABLE V. OVERVIEW OF THE CREDIBILITY AND EXPECTANCY SCORES

Factor	Median (IQR)	WSRT
Credibility	6.3 (2.7)	z = 4.690, r = 0.553, p = 0.001**
Expectancy	8.0 (3.8)	z = 5.838, r = 0.688, p = 0.001**

**Indicates highly significant, p < 0.01, *Indicates significant, p < 0.05,
r > 0.5 indicates large effect size.

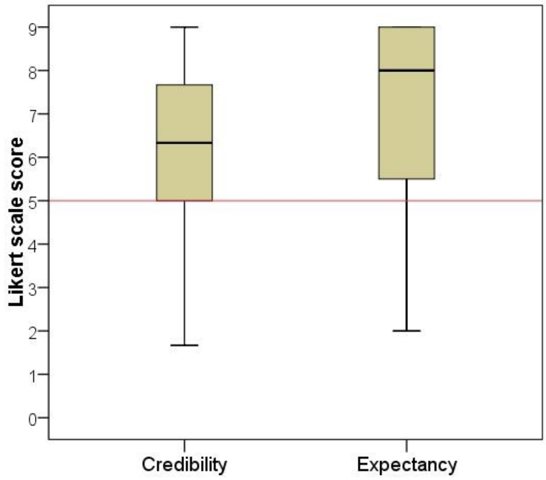

Figure 8. The boxplot for the credibility and expectancy

V. DISCUSSION

A. Discussion Concerning the Product (Cliff Prototype)

Most of the elderly first impression about Cliff is that they see an unknown electronic device. They could not guess what is the main function of Cliff. However, they are impressed with the current shape of the automatized zipper. For them, the look of the device itself is important so that the user could positively perceived the device and easily match it with their fashion style. Stigmatisation is one of the issue highlighted in our preliminary study which is related to the social wearability aspect. Cliff could be abandoned like other fully functional or high-performing devices if the importance of the aesthetics value is neglected [30]. Any products that could create an unwanted stigma can damage the user's self-esteem, and cause them to avoid from using it. Stigma is the prominent factor that sets the assistive technology (AT) apart from the medical devices or mainstream product [31].

During the interview session, the elderly said that they should not consider what the other people think about how do they look like while wearing Cliff. For them, the most important thing is the device could assist and bring benefits to them. People will use an application or a device if they believe that the function offered by the device will assist them to perform their job better [6]. According to Jacobsen, the stigma can be reduced by reshaping the meaning of the product [31]. Making it less noticeable or increase the portability of the device could be the options to reduce the stigma. The further design of Cliff should evolved towards making it more imperceptible either by reducing the current size of it or making the automatized zipper like an everyday clothing item. Therefore, a good communication through the product form is essential to ensure that the user and the society can accept the kind of assistive product like Cliff.

Another way to reduce the stigma is through the personalization [29]. Personalization will enable the user to make their choice in a product which can match and fit with their identity. This is inline with the feedback received from the participants who request to have a piece of Cliff that can match with the garments that they dressed on. Empowering the user could overcome the stigma that they feel while using any kind of assistive product [25], [32]. It is also essential to take note on the demand of the elderly to keep active while using Cliff. Having either the touch switch or the hand gesture control will enable them to use their hand actively to operate Cliff. By having these kinds of control mechanism, they think that their independency level is much higher.

B. Discussion Concerning the User Study and Design Process

The designers of the product executed the user study session. The participants might tend to please us since we are the designers (uncertainty). However, from the user study performed, the elderly look sincere to give their feedback to us. We received both positive and negative comments on the Cliff design. We also noticed that the elderly could easily understand the word and phrasing used in the questionnaire. Overall, as a designer, going through the iterative research design and the user study during the early development stage of Cliff is such a valuable experience. The interaction and input are most effective during the product ideation to maximise the efficiency of the prototype design and development. Since the participants could visually evaluate and experience the prototype, it may elicit the user perceptions and emotional responses to Cliff [33]. Furthermore, it could drive the design projects towards the finalised design solution and develop an ideal product for them. It creates a cycle that you can’t wait to start redesign again, analysing and testing the new design. The further design will focus on improving a few aspects which are 1) the aesthetics of Cliff (the looks and the size of it), 2) the attachment method (to attach Cliff to the pull tab of the zipper) and, 3) the control method (to replace the toggle switch used in the current prototype).

VI. Conclusion

In this paper, we introduced Cliff: an automatized zipper. Cliff is a kind of wearable which aimed to assist the zipping and unzipping process for individuals who have problems or difficulties to complete the task. We performed a user study to evaluate the wearability and usability of the automatized zipper with the elderly. Based on the quantitative results, the acceptance of this latest Cliff prototype is satisfactory with all the levels of effect on each comfort dimension scoring at the Low and Moderate levels. Cliff achieved the second wearability levels (WL2) which means that the system is wearable, but further improvements to the prototype need to be taken into consideration in further design. For instance, the stigmatisation issue. One of the solution to reduce the stigma is to make Cliff less noticeable by reducing the size of the device, making it portable and can be placed in the pocket, or improving the aesthetics of the automatized zipper. Size is an important factor in designing the wearable devices [34]. Secondly, the findings identified that the elderly believed that Cliff is an effective and useful device to assist them using the zipper. They agreed that the automatized zipper will reduce their difficulty to perform the zipping and unzipping task. Even if an assistive device would obviously improve the performance, it is important that the users perceived it as useful to ensure that they will use it [6]. Regarding the perceived ease of use aspect, the recorded score explains that the participants accept that Cliff is easy to learn, controllable, and understandable. However, the participants mentioned that the attachment method of Cliff to the zipper on the garments need to be improved. Enhancing the attachment method is crucial to facilitate the self-wearing of the device. The easier a technology to be used, the more useful it can be [8]. Lastly, the function offered by Cliff is logical for the elderly. They are confident in recommending the device to other people who have difficulty with the zipper. The input, feedback and comments received from the user study will be used for the next design iteration as we aimed to evolve the automatized zipper towards a smaller and more user-friendly device.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Mohamad Zairi Baharom design and develop the prototype, conducted the research, analyze the data, and wrote the paper. Marina Toeters assisted in the design and development of the prototype and to design the user study session for this project. Loe Feijs and Frank Delbressine involved during the data analysis and discussion part of this research, and assist in the writing stage of the full paper. All authors had approved the final version.

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