Project Title

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Programme: MSc Data Science and Machine Learning

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Abstract

The abstract is a brief summary of the paper, which needs to be written extremely well. Try to address the following points in your abstract, with a single sentence per point. This will naturally keep the abstract compact:

1. Describe the task/problem the paper is going to address (high level)
2. Why is this an interesting/important problem?
3. How does one usually solve this?
4. How (and why) do we do it in this paper (key idea)? Highlight the novelty here.
5. Interpretation of the results (impact and importance)

Contents

Chapter 1

Introduction

Instructions for section: What is the problem and why is it interesting. State very clearly the problem that you are investigating. If your examiner cannot even understand the first few pages of your thesis, there is no chance that you will obtain a high mark.

1.1 Motivation

Nadia's comment - Try to motivate the development of affective touch recognition from sooner as discussed in my previous feedback. See how Lili does it in her thesis ... in the introduction (Chapter 1). Spend 10 min reading her CHp 1

The fashion industry is one the most significant contributors to the current climate crisis and is responsible for around 10% of global greenhouse gas emissions and approximately 20% of global wastewater. In addition to its toxic environmental impact, the fast fashion industry has substantial implications on an individual's overall well-being and finances. The fashion industry has recently been channelling digital technology to create a more sustainable and circular economy. Examples such as virtual clothing try-ons and digital clothing for virtual presence aim to lessen consumers' one-time use and return of physical clothing.

This project supports the digital initiative of creating a more sustainable and circular economy. It proposes a novel machine learning approach to infer affect from touch and tactile experience when purchasing clothes. This project's findings significantly contribute to the end goal of building a smart chatbot that learns how people touch and engage with clothes. The chatbot aims to design a fulfilling and reflective clothes shopping experience for the consumer, which will drive them to optimise their purchases and thereby reduce wasteful purchasing, resulting in a more circular and sustainable fashion industry.

Temi's comment - I think you can elaborate here on the: 1) context of the touch, i.e. fabric handling, 2) the modalities (while you are trying to infer touch experience/expressions, you are actually not using touch itself as a modality, are you? muscle activity and hand movement, which are the data that you are using, aren't touch data, e.g. like would be captured using a pressure sensor or touchscreen etc. You need to clarify so that the reader has a good idea of what your

work is about from the start. Otherwise, they can build a different picture and feel confused when they get to latter sections.

1.1.1 Fast Fashion and its Environmental Impact

Temi's comment - I think it would be helpful for this subsection to end with a sentence or two that starts to reveal to the reader how your work addresses this problem. Otherwise, you've told a nice story, but why should the reader care about it in understanding your work?

Introduction to Fast Fashion

'Fast fashion' refers to speedily and mass-produced, low-quality clothing that is quickly circulated through high street stores to satisfy the latest trends and maximise consumer demand [1]. Fast fashion garments are cheaply produced and priced and replicate the latest celebrity or catwalk styles [2, 3]. Fast fashion involves swift design, production, distribution, and marketing [2]. This allows retailers to obtain a larger quantity of assorted designs, and in turn, consumers are presented with a more extensive choice of inexpensive clothing [2].

The term 'Fast fashion' was first coined in the early 1990s by the New York Times to describe how Zara, the Spanish apparel giant, only took 15 days between designing the garment and selling it in their stores [1, 2]. The most prominent names in the current fast fashion industry include Zara, H&M (Hennes and Mauritz), Uniqlo and Gap [1, 2]. As shown in Figure 1, all four apparel manufacturers sold over $15 billion worth of clothes in the 2021 fiscal year [4].

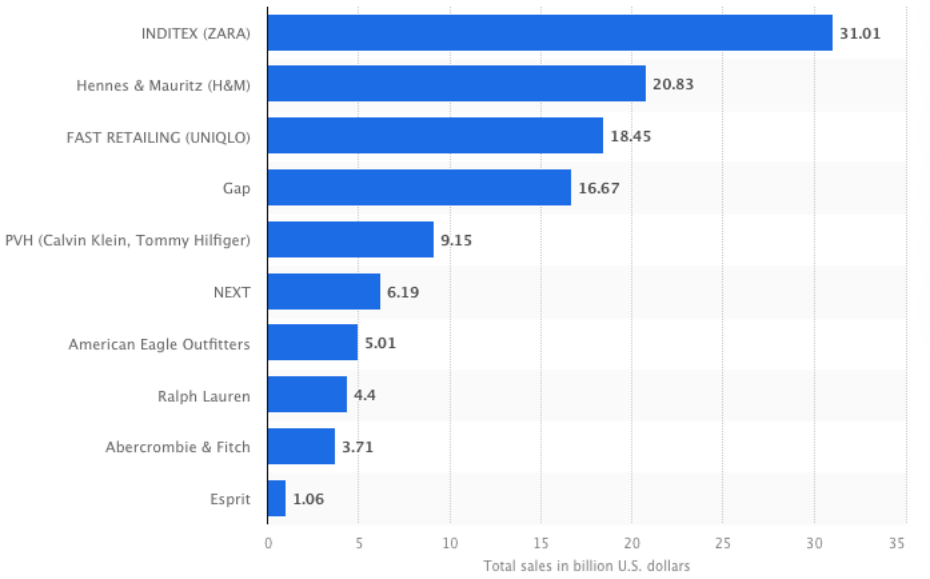

Figure 1: Sales of major apparel manufacturers and retailers worldwide in the fiscal year 2021 (in billion U.S. dollars) [4]

My comment - Include paragraph on how big fast fashion is - stats on how many people buy using fast fashion, proposed trajectories etc

As fast fashion relies on cheap and quick production, it promotes overproduction [3]. Fast fashion also encourages overconsumption because consumers are attracted to cheap and trendy clothing that copies current trends compared to relatively expensive, long-lasting items that fall out of style shortly [1, 3]. This toxic system of constantly buying clothing and almost immediately discarding them due to its low quality is the most significant pitfall of fast fashion [1, 3]. As a result, fast fashion massively harms the environment [3].

Environmental Impact of Fast Fashion

The environmental impact of fast fashion includes large-scale emission of greenhouse gases, the use of massive amounts of water and energy, and the depletion of non-renewable resources. Fast fashion is also one of the world's largest polluters.

According to the United Nations Environment Programme (UNEP), textile production accounts for up to 10% of total global carbon emissions (1.2 billion tonnes) [2, 5]. This figure is larger than the emissions from all international flights and maritime shipping combined. Further, according to the UN Framework Convention on Climate Change, global carbon emissions are estimated to skyrocket by more than 60% by 2030 [6].

The fashion industry is also the second largest consumer of the world's water supply [2, 7]. Approximately 700 gallons (3182.26 litres) of water is required to produce a single cotton shirt; this is enough water for an individual to drink at least eight cups per day for three-and-a-half years [2, 7]. Roughly 2 000 gallons (9092.18 litres) of water is used to produce a pair of jeans; this is more than enough for one person to drink eight cups per day for ten years. Further, the United Nations Environment Programme (UNEP) discovered that the fashion industry produces 20% of the world's wastewater and that fabric dyeing is the second largest water polluter because the water leftover from the dyeing process is dumped into rivers, streams, and other water bodies [8]. This severely affects marine life and the aquatic ecosystem.

Textile production is also highly energy intensive and requires large quantities of petroleum [2]. According to STAND.earth, the largest component of the fashion supply chain still relies on coal for electricity generation and heat used in apparel manufacturing [9, 10]. Burning coal releases greenhouse gases such as carbon dioxide, and such gases are the leading cause of global warming and climate change [9, 10]. Further, the global textile and apparel industry consumes 98 million tonnes of non-renewable resources [11].

Synthetic materials such as nylon, polyester and acrylic are created from fossil fuels and currently comprise over two-thirds of the materials used in the apparel industry [2, 9, 12]. Such materials take over hundreds of years to biodegrade [2]. A 2017 report from the International Union for the Conservation of Nature (IUCN) estimated that 35% of all microplastics (tiny pieces of plastics that never biodegrade) in the ocean came from laundering synthetic textiles like polyester [2, 7, 12]. It is also estimated that microplastics cause up to 31% of plastic pollution in the ocean [7, 12].

There is also massive amounts of monetary and resource wastage resulting from fast fashion. According to Business Insider, 85% of textiles of all textiles go to the landfills each year – this is enough to annually fill the Sydney harbour [7, 13, 14]. Further, the equivalent of one garbage truck full of clothes is dumped in a landfill or burned every second [7, 15].

Other Detrimental Effects of Fast Fashion

There is also a significant human cost resulting from fast fashion. Garment workers in the global South pay a large price so fast fashion brands can keep their profit margins high and price tags low [16]. Garment workers are paid well below the liveable wage and are forced to work long, strenuous hours in abysmal conditions. An Oxfam 2019 report discovered that 0% of Bangladeshi and 1% of Vietnamese garment workers earned a living wage [17, 18]. Nine of 10 Bangladeshi workers starve because they cannot afford food, and three-quarters cannot afford medical treatment [17, 19, 18]. In Vietnam, more than half of workers cannot afford medical treatment, and three-quarters of workers cannot afford to make ends meet in general. Garment workers are often forced to work 14 to 16 hours a day, seven days a week [17, 18]. The devastating Rana Plaza collapse in 2013, which killed 1134 people and injured 2500 others, is a testament to the unacceptable working conditions in the fashion industry [16, 19]. Employees usually work without ventilation and inhale toxic substances such as fibre dust or blasting sand [20]. Accidents, fires, injuries, and diseases frequently occur on apparel production sites [20].

Animals are also adversely affected by fast fashion. The toxic dyes and microplastics released into waterways are ingested by animals, most often resulting in their deaths [3]. Using animal products such as leather, fur, and wool directly risks animal welfare [3].

My comment - Include bridging sentence or paragraph to connect touch and adverse effects of fast fahion

1.1.2 The Importance of Touch when Purchasing Clothes

Multiple studies have discovered that consumers heavily rely on affective touch and tactile experience when purchasing clothes. According to [21], affective touch is defined as tactile processing with a hedonic or emotional component; in summary, it is the emotional aspect of touch.

[22] discovered that touching an object may increase consumer confidence in product assessment and evaluation. Other studies also observed that tactile input is preferred over macro-spatial characteristics (shape and size) when assessing an item's physical properties (such as softness, smoothness, flexibility) unless there was no way to pass visual judgment [23, 24]. According to a study led by Holbrook [25], tactile cues were more important than visual cues in consumer perception and assessment of sweaters. Moreover, the principal effect of tactile cues may differ from one item to another [26]. For example, consumers will rely more on tactile inputs when assessing some objects (a coat with various properties such as weight, thickness, texture) than others (a standard AAA battery. Therefore, touch is a crucial criterion when assessing items that differ in their textual properties [27]. Therefore, it is plausible that conscious or unconscious tactile

emotions (affective touch) play a leading role in consumer perception of clothing.

With the expansion of fast fashion and the development of the internet, online clothes shopping has become increasingly popular. However, this comes with the caveat that individuals cannot physically touch and engage with the clothes they purchase. Multiple studies on internet retail [28, 29] have confirmed that the main drawback of online shopping is the inability of the consumer to touch the products. Therefore, consumers find it challenging to develop a comprehensive evaluation of the product they are purchasing purely through online shopping. Studies have also discovered that some consumers feel frustrated or disappointed if they do not have the opportunity to touch and examine the products in real life; this is particularly true for consumers who have a higher need for touch (NFT) [22, 28].

My comment - Talk about how people don't engage with clothes when they shop fast fashion

Temi's comment - Again, this subsection should end with a few sentences on how work addresses any limitations highlighted. Otherwise, it will read like a nice but irrelevant story.

1.2 Objective

Temi's comment - I think it will be more helpful to start with the aim/objective of your own thesis (rather than the aim of the larger project). You can then elaborate including providing the context and application that you envision it's use/value. The elaboration on your own work itself should be more detailed (than elaboration on the larger project).

The long-term aim of this project is to build a chatbot that helps reduce fast fashion's impact. The chatbot aims to transform clothes shopping into a multi-sensory, reflective and recognition-based experience. Firstly, the chatbot will ask individuals to touch new clothes, engage with the fabric, **reflect** on whether they like the garment and if they will wear it. Secondly, the chatbot will have stored information such as what clothes the individual has in their cupboards, what their favourite and most worn clothes are and what type of clothes they like. Based on this data, the chatbot will look at the cloth the individual is looking at and **recognise** if the individual likes it and will wear it.

Past studies have discovered and confirmed that consumers rely heavily on affective touch and tactile experience when purchasing clothes. Therefore, developing a method to comprehensively understand what an individual experiences when touching a textile, how they feel after touching it, and if they like it may help to reduce the impact of fast fashion. Therefore, this study proposes a novel machine learning approach to estimate people's sensations and their liking of the textile being touched.

1.3 Project Outline

This paper is organised as follows.

My comment - Include paragraph on paper organisation

Chapter 2

Background and Related Work

Describe here work that is connected to your thesis. This should include references to published work. There is no fixed rule, but I would expect a student to have read around 50 published research papers and reference them in a thesis.

Touch is the most advanced sensory function at birth and plays a vital role in emotional, social, cognitive, and cerebral development throughout infancy and childhood [30, 31, 32, 33, 34]. In the words of Michelangelo, 'to touch is to give life'. This statement is further corroborated by a study conducted by Tiffany Field, which observed that premature newborns who received touch therapy for 5-10 days gained almost 50% more weight than preterm newborns who received standard medical treatment [30, 35]. Touch continues to play an essential role through adolescence and adulthood as it is used to express various emotions and manoeuvre various situations [33, 34, 36]. Touch also plays a significant role among nonhuman primates. Nonhuman primates groom each other for 10 to 20 per cent of their day to soothe, reconcile, reinforce reciprocity and build cooperative alliances [35, 37].

Recent studies discovered that touch has incredible health benefits. Touch reduces illness, strengthens the immune system, reduces pain, enhances sleep, soothes, and signals safety and trust [30, 35, 38]. For example, [39] observed that premenopausal women who received more frequent hugs from their partners had lower blood pressure and heart rates. Hugs have also been found to strengthen the immune system - the gentle pressure applied on the sternum when hugging stimulates the thymus gland, which regulates and balances the production of white blood cells. Further, touch increases levels of dopamine and serotonin (2 neurotransmitters that relieve stress and anxiety) and reduces cardiovascular tension by releasing oxytocin ('the love hormone') and activating the vagus nerve (involved in showing compassion) [35, 40].

2.1 Emotion Recognition through Touch

Temi's comment - You have focused here on the context of human-human touch. You need to at least also include a few more relevant studies such as on human-object/computer touch. You should also at least mention the distinction between human-human/robot touch and human-object/computer touch. Does it matter when it comes to the ML or not (e.g. in the former where

the intent may usually be communication or affect vs in the latter where the purpose of touch may be different such as simply functional)? And I think that rather than focusing on social sciences or HCI studies (alone), you need to cover ML studies especially those with settings and/or sensors most relevant to your work?

As humans, we use touch in our daily life for various reasons. We rely on touch to perform actions such as flirting (gently stroking face, hair, or arm), attracting attention (waving hands), offering congratulations (handshake or a pat on the back), and when thanking others (hugging and gently squeezing). We also express emotions such as love (embracing, hugging, and stroking), sympathy (embracing, stroking back), fear (squeezing hand) and anger (gently slapping) through touch.

Touch is such an integral part of our lives that the word stem 'touch' is explicitly and metaphorically used to express emotion. For example, if an individual is 'touched beyond words', they are so overcome by emotion that they cannot speak. The following phrases metaphorically use touch to convey emotion - 'touched their heart' refers to making someone feel sympathy, and 'touched their soul' refers to having a profound effect on someone.

Although touch plays an essential role in human life, it has received less attention in affective science than facial and vocal displays of emotion [34, 41]. Initially, studies regarding touch as an affective modality claimed that it was mainly used to communicate the hedonic tone of emotions (positive and negative) [33, 41, 42, 43, 44, 45] and increase the intensity of emotion-related communication [33, 45]. However, two consecutive studies by Hertenstein in 2006 and 2009 have argued that touch plays a much larger role in emotional communication.

The first study discovered that participants could identify several distinct emotions when they were touched on their forearm by their partner (a stranger), even though they could not communicate visually or verbally [33, 41]. This study observed that the tactile modality could distinguish between the emotions of love, gratitude, sympathy, fear, disgust and anger with accuracy rates between 48% and 83% [33]. The second study confirmed these results and observed that happiness and sadness could also be recognised with accuracy rates higher than chance [34, 41]. Therefore, the recognition performance attained with touch alone was comparable to those observed in studies of facial displays and vocal communication [33, 41, 46, 47].

The second study investigated 23 types of tactile behaviour (ex: squeezing, stroking, pushing) and revealed systematic differences in how touch was used to communicate different emotions [34, 41]. For example, love was associated with stroking; gratitude was associated with shaking of the hand; sympathy was associated with stroking and patting; disgust was associated with a pushing motion; fear was associated with trembling and anger was associated with hitting and squeezing [34]. However, as some types of tactile behaviour were used to communicate multiple emotions (for example, stroking was used to express both love and sympathy), the study concluded that tactile behaviour alone is insufficient to differentiate between different affective emotions [34, 41].

This paper also found that emotions could be categorized according to differences in intensity

and duration [34]. For example, love and sympathy were characterized by a moderate-intensity touch for a longer duration, whereas anger was characterized by a vigorous intensity of touch for a moderate duration [34].

My comment - Insert paragraph on how we change our muscle activity to signal emotion

Temi's comment - People don't necessarily "change" muscle activity to signal emotion. Your framing assumes the context of emotion communication. I think you should instead reframe as emotion experience since that is more appropriate for the touch setting in your data. The participants are not touching the fabric in a way as to communicate an emotion. Rather, they are touching the fabric and this activity has associated with it an experience which may relate with how they touch the fabric (the way they touch the fabric can be captured using sensors such as muscle activity or movement sensors).

The machine learning community commonly uses the psychology behind affective touch and change in muscle activity to perform affective touch to inform the design of features used in machine learning models.

2.2 Human Activity Recognition using Machine Learning

2. How is this this knowledge used to inform ML techniques (automatic recognition, feature base etc)
This project builds on the findings of Lili Lin [48].

Chapter 3

Methodology

Describe your method in detail and with great clarity, distinguishing it from other works (if it is indeed a novel idea). It is very important to clearly motivate your method. Describe the results of your method here in this chapter.

3.1 Data collection

My comment - Intro para like lili's - reiterate aim

The data used in this project was collected in two rounds. The first round of data collection was conducted in 2021 by Lili Lin as part of her MSc Final project. The author and two other postgraduate students conducted the second round as part of our MSc Final projects. Both studies were approved by the UCL Research Ethics Committee (Project ID Numbers: 5095/00167 [48] and 4831 respectively). The latter round of data collection was conducted for two main reasons. Firstly, the author wanted to expand the data collected in round one so that the machine learning models would have a larger input dataset. Secondly, the author wanted to observe if a model built using the data collected in round one could generalize to a new type of garment that the model had never seen before (sock data collected in round 2).

3.1.1 Participants

Nine participants (eight females and one male) were recruited in round one [48]. Eight were students of the Human Computer Interaction department at University College London (UCL), while one was from another university [48]. These participants were all Chinese and righthanded [48]. Participants received an amazon voucher worth £35 as a reward for their time [48].

Round two consisted of six participants (three females and three males). Five participants were PhD students at University College London, and one was a visiting researcher at University College London Interaction Centre (UCLIC). Five out of the six participants were right-handed, whereas the other was left-handed. Participants received an amazon voucher worth £15 as a token of appreciation for their participation.

3.1.2 Equipment and software

Both rounds used the same equipment (except for the clothes) and software for data collection.

1. **Armband with sensors**: Two OYMotion gForcePro+ EMG Armbands (refer Figure 2) were used to collect raw EMG (Describe what EMG is) and motion data from the participants' left and right hands (the armbands were labelled to differentiate between the left and the right). These armbands are examples of smart wearable human interface devices used for gesture recognition [49]. Each armband contains eight extremely sensitive EMG sensors with differential dry electrodes, nine-axis IMU (Describe what IMU is) motion sensors and communicates using Bluetooth BLE 4.2.[50, 48]. The armbands recognize gestures according to the sEMG signals of human forearms and calculate orientation data in quaternions or Euler Angles using its built-in nine-axis IMU sensors [49].

Figure 2: OYMotion gForcePro+ EMG Armband [49, 50]

2. **Phone**: A Motorolla moto g^9 power phone (refer Figure 3) with both the GForceTextileHand App [48] developed by Lili Lin and the gForceApp [50] developed by OYMotion installed were used to collect the data. This phone uses Android 10 with a Qualcomm® Snapdragon™ 662 processor and Bluetooth® 5.0 as its operating system [51, 48].

3. **Clothes**: Each participant in round one could choose six different clothes from their wardrobe. The only limiting criterion was that they had to choose different types of clothes with different properties and tactile experiences. All participants in round two touched the same six socks depicted in Figure 4.

4. **Software**: The GforceTextileHand app was mainly used for data collection, whilst the gForceApp was also used. The user interface for the GforceTextileHand is given in Figure 5 [48]. The software used in this app employed SQLite to store experimental, EMG, Euler Angle and IMU (accelerometer, gyroscope, magnificent, and quaternion) data [48]. SQLite is a C-language library that implements a fast and high-performance SQL database engine [48, 52]. This project only uses the EMG, accelerometer and quaternion data for two main

Figure 3: Motorolla moto g^9 power phone [51]

Figure 4: Socks used in round 2

reasons. Firstly, some data was very noisy and had *Gimbal lock problems (*Gimbal lock occurs when the axes of two gimbals in the three-gimbal device are driven into a parallel configuration, thereby losing a single degree of freedom and "locking" the system into rotation in two-dimensional space [53, 54]) Secondly, due to time constraints involved.

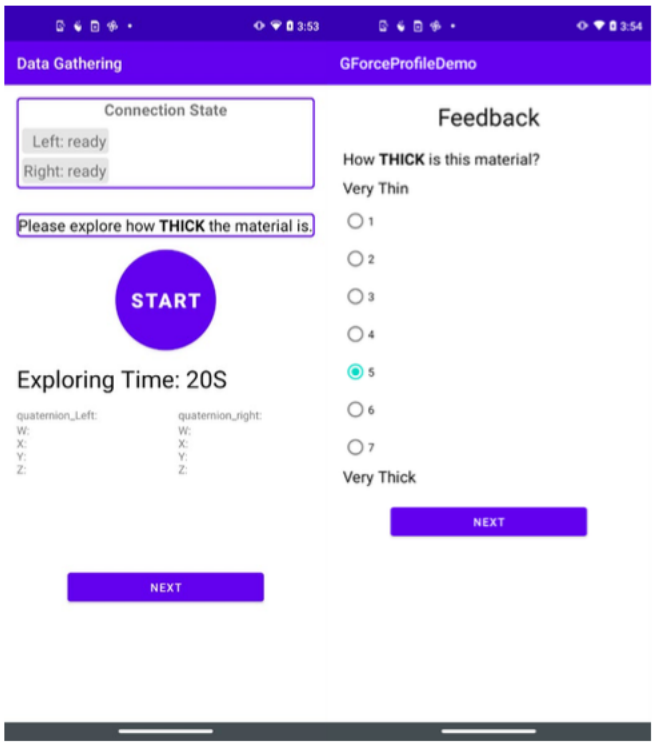

Figure 5: Sample User Interface of theGforceTextileHand App [48]

3.1.3 Experimental design

In both rounds, participants had to assess six properties (five physical properties and enjoyment) for each item of clothing. The five physical properties evaluated were smoothness, thickness, warmth, flexibility and softness. Lili Lin selected these properties in round one based on the study done by Gao [48, 55]. However, durability was replaced by flexibility as [55] discovered that durability was challenging to identify using only touch [48]. Participants were asked to rate each property on a scale from 1 to 7. Ratings for each property were obtained using Likert scale questions with seven choices (for example, for the flexibility property, 1 was not at all flexible, and 7 was very flexible).

The EMG, accelerometer and quaternion data were obtained using the armbands mentioned in section 3.1.2. The armbands were worn as indicated in Figures 6 and 7. As shown, armbands on the left and right should be worn differently (the armband on the left should have the USB port facing the elbow, and the one on the right should have its USB port facing the wrist). This is so that when recording the data, the EMG channels are the same, but the IMU data signs are swapped.

In the first round, each participant recorded the data in their house by themselves. In the second round, the experiment was conducted by the author and the other two students at UCLIC.

3.1.4 Experimental procedure

An almost identical experimental procedure was followed in both rounds. As mentioned before, the only difference was the experiment's location. For both rounds, the participants were sent an information sheet by email and were asked to sign the consent form via REDCap before the experiment started. The data collection process consisted of two components. Firstly, a baseline reading was obtained. Then the EMG and movement data were obtained as follows.

1. Before assessing the six properties for a cloth, participants received 10 seconds to touch the cloth freely, engage with it, and determine how they wanted to touch it to best assess the properties.
2. The participants touched the given item of clothing for a pre-determined time period and assessed the particular physical property.
3. Then, they rated the property on a Likert scale with values ranging from 1 to 7.
4. Steps 2. and 3. were repeated for the remaining four physical properties.
5. The participants touched the cloth for a pre-determined period of time and explored how enjoyable it was to touch the cloth using their preferred gestures.
6. The enjoyment gained from touching the cloth was then rated on a scale from 1 to 7.
7. The participants were then asked to reflect on their feelings when touching the cloth and comment on it. This included anything they enjoyed or disliked and whether the item of clothing had any characteristic features.
8. Steps 1-7 were repeated for the remaining five items of clothing.

There were two main aims of obtaining the baseline readings [48]. The first aim was to check if the participants were wearing the armbands correctly. The position of the armbands (how high or low they sit on the forearm) varied depending on variables such as participants' gender and forearm circumference. This difference could also affect the data collected because if the participant had a smaller forearm circumference, the sensors on the armband might not have continuously had contact with the participant's skin. Therefore, the second aim was to compare the differences among participants and normalize the data if necessary.

The participant had to perform two tasks when recording the baselines as part of the procedure. Firstly, the participants had to lay both arms, relaxed on the table, palms facing upwards (as shown in Figure 6). This was to record the minimal contraction of a participant's muscles. Secondly, the participants had to clench their hands into a fist as tightly as possible (refer Figure 7) to record the maximum contraction of muscles.

After freely touching the cloth, participants would touch the cloth for a pre-determined time period to assess each property. In round one, the pre-determined period was 20 seconds, as determined by previous studies [55, 56]. In round two, the time was shortened to 15 seconds for fear that the participants would get bored and not fully cooperate. In round one, the order of assessing

Figure 6: Baseline 1 - Relaxed

Figure 7: Baseline 2 - Fist

properties was fixed for each garment, and each participant [48]. This was because the participant conducted the experiment, and Lili Lin wanted to keep the experimental procedure simple and uncomplicated. However, the order of properties assessed for each cloth and the order of clothes for a participant were randomized in round two. This order can be observed in Appendix A.

After touching the item of clothing for the pre-determined time to explore a property, participants were asked to rate the property on a Likert scale with values ranging from 1 to 7. For example, when assessing the property flexibility, 1 would signify that the cloth is not at all flexible (very stiff), and 7 represented a very flexible cloth.

It is important to note that the participants were not explicitly informed how to touch the clothes – they were free to touch the clothes as they pleased when assessing properties.

3.2 Data pre-processing

Both rounds had three initial datasets because the EMG, accelerometer and quaternion data were collected separately. The same data pre-processing steps were used in both rounds to preserve uniformity.

Firstly, the baseline readings and free exploration data were removed from all three datasets. Then, the rating data was attached to each of the datasets.

The EMG data was collected via eight channels. The collected was rectified and normalised. Raw EMG data usually consist of both positive and negative components. Rectification refers to translating raw EMG signals to a signal with a single polarity (usually positive) [57, 58]. This is done so that the EMG signals do not average zero. The two main types of commonly used rectification methods are half-wave rectification, and full-wave rectification [57]. Full-wave rectification was used in this project because it preserves the data and does not cause a loss in data, whereas half-wave rectification removes some signals [57, 59]. Full wave rectification translates data below

the baseline to data above the baseline so that all data is positive [57]. If the baseline is zero, this is equivalent to taking the absolute value of the signal [60]. The data for both rounds were centred around 120. Therefore, the EMG data was first centred on zero, and then the absolute value was obtained. Normalisation was the second step of the EMG pre-processing process and refers to the conversion of the EMG signal to a relative scale by a reference value [61]. As EMG signals are inherently prone to variability, these signals require normalisation for physiologic interpretation and comparison between different participants [62]. The data was normalised by splitting according to the left and right hands and then dividing the data in each channel by the maximum observed signal (in the channel). My comment - Is this the same as MVC (Maximum Voluntary Contraction

My comment - Accellerometer

My comment - Quaternion

My comment - Subwindows and slices, why didn't I use dynamic windows

The distribution of ratings by property for the xxx dataset can be observed in Figure 8 (top). It can be observed that this distribution is imbalanced and that the modal (most occurring) class varies across the properties. Based on this distribution, the rating levels were grouped as follows: 1-2 into 'low', 3-5 into 'medium' and 6-7 into 'high'. As observed in Figure 8 (bottom), this grouping works very well for some properties such as flexibility and softness but not so well for others. Rating was grouped for two main reasons. Firstly, rating was very subjective and would greatly vary across individuals. Secondly, the dataset was relatively small and thus would present problems if all seven levels were used in granular modelling [48].

3.3 Models

3.4 Results

3.5 Dataset

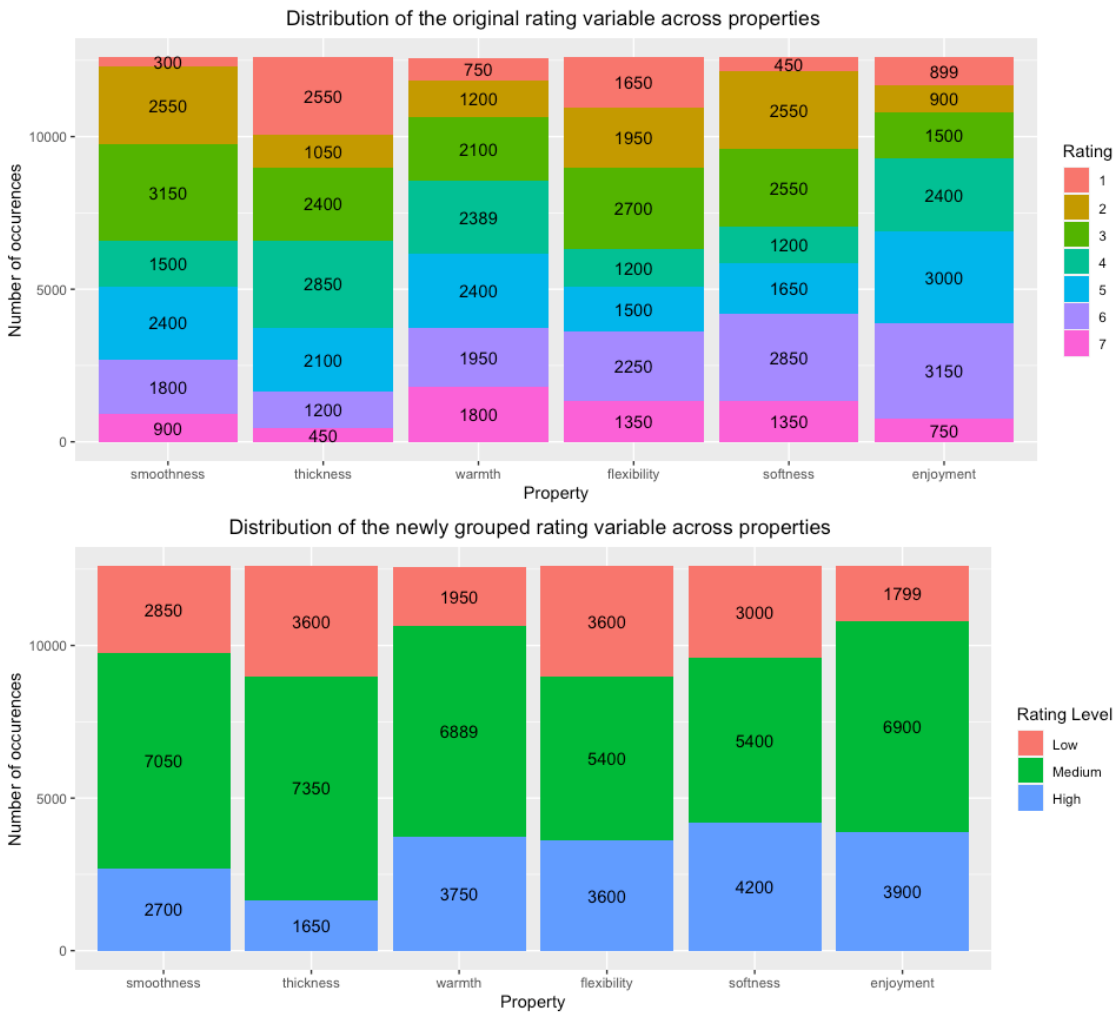

Figure 8: Distribution of the rating variable across properties

Chapter 4

Extensions of Methodology

It is unlikely that everything you tried worked well, so in this chapter you may wish to describe a modified version of your method and the associated results. Explain why you were motivated to try this extension and how you think it might help to address some of the shortcomings of the method is Chapter 3.

Chapter 5

Conclusion

Summarise what you have achieved and evaluate honestly if you feel the approach has been largely successful. Explain what could be improved still and perhaps why the method is not working well (if that is the case).

Bibliography

[1] Olivia Lai. What is fast fashion? https://earth.org/what-is-fast-fashion/, Nov 2021. (accessed: 07/08/2022).

[2] Rashmila Maiti. Fast fashion and its environmental impact. https://earth.org/fast-fashions-detrimental-effect-on-the-environment/, Jun 2022. (accessed: 07/08/2022).

[3] Solene Rauturier. What is fast fashion and why is it so bad? https://goodonyou.eco/what-is-fast-fashion/, Apr 2022. (accessed: 07/08/2022).

[4] Paul Smith. Sales of selected fashion manufacturers/retailers worldwide in 2021. https://www.statista.com/statistics/242114/sales-of-the-leading-10-apparel-retailers-worldwide/, Jun 2022. (accessed: 07/08/2022).

[5] Rachael Dottle and Jackie Gu. The global gut of clothing is an environmental crisis. https://www.bloomberg.com/graphics/2022-fashion-industry-environmental-impact/#xj4y7vzkg, Feb 2022. (accessed: 09/08/2022).

[6] United Nations. Fashion industry, un pursue climate action for sustainable development. https://unfccc.int/news/fashion-industry-un-pursue-climate-action-for-sustainable-development, Jan 2018. (accessed: 09/08/2022).

[7] Morgan McFall-Johnsen. The fashion industry emits more carbon than international flights and maritime shipping combined. here are the biggest ways it impacts the planet. https://www.businessinsider.com/fast-fashion-environmental-impact-pollution-emissions-waste-water-2019-10?r=US&IR=T, Oct 2019. (accessed: 09/08/2022).

[8] Waste2Fresh. Dye pollution in the textile industry. https://waste2fresh.eu/dye-pollution-in-the-textile-industry/, Jun 2021. (accessed: 09/08/2022).

[9] Gary Cook and Maya Rommwatt. Fashion forward: A roadmap to fossil free fashion. https://www.stand.earth/sites/stand/files/standearth-fashionforward-roadmaptofossilfreefashion.pdf. (accessed: 09/08/2022).

[10] Common Objective. The issues: Energy. https://www.commonobjective.co/article/the-issues-energy, 2021. (accessed: 09/08/2022).

[11] China National Textile Office for Social Responsibility and Apparel Council. Outlook for a new textile economy in china. https://www.switch-asia.eu/resource/make-fashion-circular/, 2020. (accessed: 09/08/2022).

[12] Julien Boucher and Damien Friot. *Primary Microplastics in the Oceans: A Global Evaluation of Sources*. Jan 2017.

[13] The United Nations Economic Commission for Europe. Fashion and the sdgs: what role for the un? https://unece.org/fileadmin/DAM/RCM_Website/RFSD_2018_Side_event_sustainable_fashion.pdf, Mar 2018. (accessed: 09/08/2022).

[14] Elizabeth Reichart and Deborah Drew. By the numbers: The economic, social and environmental impacts of "fast fashion". https://www.wri.org/insights/numbers-economic-social-and-environmental-impacts-fast-fashion, Jan 2019. (accessed: 09/08/2022).

[15] United Nations Environment Programme. Putting the brakes on fast fashion. https://www.unep.org/news-and-stories/story/putting-brakes-fast-fashion, Nov 2018. (accessed: 09/08/2022).

[16] Martyna Lesniak. The human cost of cheap, fast fashion: 8 years after rana plaza. https://europeandme.eu/the-human-cost-of-cheap-fast-fashion-8-years-after-rana-plaza/, Jun 2021. (accessed: 15/08/2022).

[17] Oxfam. https://www.oxfam.org.au/what-she-makes/. (accessed: 15/08/2022).

[18] The Borgen Project. How oxfam is creating a fair fashion industry. https://borgenproject.org/fair-fashion-industry/, Jan 2022. (accessed: 15/08/2022).

[19] Jaclyn McCosker. The impact of fast fashion on garment workers. https://goodonyou.eco/impact-fast-fashion-garment-workers/, Apr 2021. (accessed: 15/08/2022).

[20] Mathilde Charpail. What's wrong with the fashion industry? https://www.sustainyourstyle.org/en/working-conditions, 2017. (accessed: 15/08/2022).

[21] India Morrison. Ale meta-analysis reveals dissociable networks for affective and discriminative aspects of touch. *Human Brain Mapping*, 37, Feb 2016.

[22] Joann Peck and Terry Childers. To have and to hold: The influence of haptic information on product judgments. *Journal of Marketing - J MARKETING*, 67:35–48, Apr 2003.

[23] Roberta L. Klatzky and Susan J. Lederman. There's more to touch than meets the eye: The salience of object attributes for haptics with and without vision. *Journal of Experimental Psychology*, 116(4):356–369, 1987.

[24] Susan J. Lederman, Georgie Thorne, and Bill Jones. Perception of texture by vision and touch: multidimensionality and intersensory integration. *Journal of experimental psychology. Human perception and performance*, 12(2):169–80, 1986.

[25] Morris B. Holbrook. Aims, concepts, and methods for the representation of individual differences in esthetic responses to design features. *Journal of Consumer Research*, 13 4:337–347, 1986.

[26] Deborah Brown Mccabe and Stephen M. Nowlis. The effect of examining actual products or product descriptions on consumer preference. *Journal of Consumer Psychology*, 13:431–439, 2003.

[27] Bianca Grohmann, Eric R. Spangenberg, and David E. Sprott. The influence of tactile input on the evaluation of retail product offerings. *Journal of Retailing - J RETAIL*, 83:237–245, Apr 2007.

[28] Alka Varma Citrin, Donald E. Stem, Eric R. Spangenberg, and Michael J. Clark. Consumer need for tactile input: An internet retailing challenge. *Journal of Business Research*, 56(11):915–922, 2003. Strategy in e-marketing.

[29] Deborah H. Lester, Andrew M. Forman, and Dolly Loyd. Internet shopping and buying behavior of college students. *Services Marketing Quarterly*, 27:123 – 138, 2005.

[30] Tiffany Field. *Touch*. MIT Press, 1st edition, 2001.

[31] Matthew J. Hertenstein. Touch: Its communicative functions in infancy. 2002.

[32] Dale M. Stack. The salience of touch and physical contact during infancy: Unraveling some of the mysteries of the somesthetic sense. 2007.

[33] Matthew J. Hertenstein, Dacher Keltner, Betsy App, Brittany A. Bulleit, and Ariane R. Jaskolka. Touch communicates distinct emotions. *Emotion*, 6(3):528–33, 2006.

[34] Matthew J. Hertenstein, Rachel Holmes, Margaret E. McCullough, and Dacher Keltner. The communication of emotion via touch. *Emotion*, 9(4):566–73, 2009.

[35] Dacher Keltner. Hands on research: The science of touch. `https://greatergood.berkeley.edu/article/item/hands_on_research`. (accessed: 26/08/2022).

[36] Iren Eibl-Eibesfeldt. *Human Ethology*. 1989.

[37] Frans B. M. de Waal. *Peacemaking among Primates*. Harvard University Press, 1989.

[38] Janette Neuwahl Tannen. Scholar touts the advantages of touch. `https://news.miami.edu/stories/2020/04/scholar-touts-the-advantages-of-touch.html`, Apr 2020. (accessed: 26/08/2022).

[39] Kathleen C. Light, Karen M. Grewen, and Janet A. Amico. More frequent partner hugs and higher oxytocin levels are linked to lower blood pressure and heart rate in premenopausal women. *Biological Psychology*, 69(1):5–21, 2005. Current Trends in Women's Health Research.

[40] Sara Menges. The 3 biggest advantages of human touch may surprise you. https://plushcare.com/blog/advantages-of-human-touch-hugs/, Jan 2021. (accessed: 26/08/2022).

[41] Yuan Gao, Nadia Bianchi-Berthouze, and Hongying Meng. What does touch tell us about emotions in touchscreen-based gameplay? *ACM Trans. Comput.-Hum. Interact.*, 19(4):31:1–31:30, Dec 2012.

[42] Matthew J. Hertenstein. *Touch*, volume 3. Sage Publications, 2005.

[43] Matthew Hertenstein and Joseph Campos. Emotion regulation via maternal touch. *Infancy*, 2:549 – 566, Oct 2001.

[44] Stanley E. Jones and A. Elaine Yarbrough. A naturalistic study of the meanings of touch. 1985.

[45] Mark L. Knapp and Judith A. Hall. *Nonverbal Communication in Human Interaction*. 1997.

[46] Hillary Elfenbein and Nalini Ambady. On the universality and cultural specificity of emotion recognition: A meta-analysis. *Psychological bulletin*, 128:203–35, Apr 2002.

[47] Klaus R. Scherer, Tom Johnstone, and Gundrun Klasmeyer. *Vocal expression of emotion*. Oxford University Press, 2003.

[48] Lili Lin. Inferring fabric-hand perception from wearable sensors. https://uclic.ucl.ac.uk/content/2-study/4-current-taught-course/1-distinction-projects/15-21/lin_lili_2021.pdf, 2021. (accessed: 15/08/2022).

[49] OYMotion. gforcepro/gforcepro+ armband and gforceoct module user guide. https://oymotion.github.io/gForcePro/gForcePro/, Aug 2020. (accessed: 15/08/2022).

[50] OYMotion. gforce emg armband user guide. https://oymotion.github.io/assets/downloads/gForce-EMG-ARMBAND-User-Guide-202108.pdf. (accessed: 15/08/2022).

[51] Motorolla. Motorolla - motog^9 power. https://www.motorola.co.uk/smartphones-moto-g-power-gen-9/p. (accessed: 15/08/2022).

[52] Sqlite home page. https://www.sqlite.org/index.html. (accessed: 15/08/2022).

[53] Jonathan Strickland. What is a gimbal – and what does it have to do with nasa? https://science.howstuffworks.com/gimbal.htm. (accessed: 15/08/2022).

[54] Adrian Popa. What is meant by the term gimbal lock? http://www.madsci.org/posts/archives/aug98/896993617.Eg.r.html. (accessed: 15/08/2022).

[55] Yuhan Gao. Automatic recognition of properties assessed in the tactile exploration of textiles. https://uclic.ucl.ac.uk/content/2-study/4-current-taught-course/1-distinction-projects/13-19/gao_yuhan_2019.pdf. (accessed: 15/08/2022).

[56] Kejia Wang. Using emg and accelerometer to capture the tactile experience with fabrics. 2017.

[57] M Raez, Md Hussain, and Faisal Mohd-Yasin. Techniques of emg signal analysis: Detection, processing, classification and applications. *Biological procedures online*, 8:11–35, Feb 2006.

[58] David M. Thompson. Electromyography (emg). `https://ouhsc.edu/bserdac/dthompso/web/pk/emg/emg.htm`. (accessed: 15/08/2022).

[59] Leandro R. Altimari, Marcelo Bigliassi, José L. Dantas, Thiago F. D. Kanthack, Antonio C. Moraes, and Taufik Abrão. Influence of different strategies of treatment muscle contraction and relaxation phases on emg signal processing and analysis during cyclic exercise. 2012.

[60] William Rose. Electromyogram analysis. `https://www1.udel.edu/biology/rosewc/kaap686/notes/EMG%20analysis.pdf`. (accessed: 15/08/2022).

[61] Alexandre Chalard, Marie Belle, Emmeline Montané, Philippe Marque, David Amarantini, and David Gasq. Impact of the emg normalization method on muscle activation and the antagonist-agonist co-contraction index during active elbow extension: Practical implications for post-stroke subjects. *Journal of Electromyography and Kinesiology*, 51:102403, 2020.

[62] Gregory J. Lehman and Stuart M. McGill. The importance of normalization in the interpretation of surface electromyography: A proof of principle. *Journal of Manipulative and Physiological Therapeutics*, 22(7):444–446, 1999.

Appendix A

Appendix

A.1 Information Sheet used in round 2

UCL INTERACTION CENTRE
RESEARCH•CONSULTANCY•SEMINARS•COURSES

UCL Interaction Centre
2nd floor, 66 – 72 Gower St
London WC1E 6EA

INFORMATION SHEET FOR PARTICIPANT

Project Title: TCC: Affective sensing technology: **The affective tactile language in clothing attachment**

Department: University College London Interaction Centre

Researcher: Yuanze Gan yuanze.gan.20@ucl.ac.uk, Alice Sansoni, a.sansoni@ucl.ac.uk, Nihara Warawita nihara.warawita.21@ucl.ac.uk,

Principal Researcher: Prof Nadia Berthouze, nadia.berthouze@ucl.ac.uk

Data Protection Email: data-protection@ucl.ac.uk

This study has been approved by the UCLIC Research Ethics Committee: UCLIC_2021_018_Berthouze_PE

1. Invitation Paragraph

You are being invited to take part in a research project. Before you decide whether to take part, it is important for you to understand why the research is being done and what participation will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

2. What is the project's purpose?

This project is part of the Textile Circularity Centre (TCC) funded by UK Research & Innovation, to understand important factors in sustainable fashion consumption and facilitate the development of a textile circular economy.

In this project, we explore the role of touch when buying clothes, or its role in building and expressing attachment. Specifically, we want to understand how gestures and movements with items correspond to different material properties and how much the cloth represents that property by using sensing technology. The extracted data could be visualised help material understanding. Our findings will inform the design of technology which encourages consumers to connect with and reflect upon their clothing items, to facilitate sustainable and circular textile consumption.

Information about the larger Textile Circularity Centre project can be found at: https://www.rca.ac.uk/research-innovation/research-centres/materials-science-research-centre/textiles-circularity-centre/.

3. Why have I been chosen?

We are asking people caring about the sense of touch when interacting with clothes, living in London and are at least 20 years-old to take part in our study.

4. Do I have to take part?

It is up to you to decide whether or not to take part in this study. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a consent form. You can withdraw from the study at any time and without giving a reason. You will not in any way be penalised for withdrawing from the study.

You can additionally withdraw data collected during the study up till 2 days after your study session, without giving a reason. To withdraw from the study or withdraw your data, you should contact the researcher, using the contact details at the top of this information sheet. We will no longer use data that you withdraw if it is withdrawn no more than 2 days after the last data we collected from you. If you choose to withdraw from the study, you will be asked to revoke your original consent by signing a consent change form.

5. What will happen to me if I take part?

You will be asked to wear two Armbands [GForcePro+] (http://www.oymotion.com/en/product32/149). This armband measures the muscle activity in your arm and your arm movement. They do not harm your skin or hurt you in anyway. We use these devices to measure the muscle activity and movement of your arm while touching the six sample clothes you will be asked to engage with during the experiment. You will be asked to freely touch 6 items assessing different properties (e.g., its softness) of the fabrics. A mobile app will guide you in the use of the sensors and allow you to complete a questionnaire during the experience. The questionnaire will ask you to rate the properties of the clothes material after touching it. We will take a video of you while touching the fabrics, trying to avoid including your face, keeping only your hands and arms. The goal of this study is to use EMG data to build a AI-system that can infer your perception of the fabric qualities. The study will last 1h 15min.

The study will follow COVID-19 safety measures (see at the end of this information sheet for covid-safety procedure)

DEVICES:

- All of our study devices (smartphone, EMG band) are cleaned and disinfected after each participant.
- The researchers will use gloves to give you the devices

6. Will I be recorded and how will the recorded media be used?

NO ONE outside of our research team will be allowed access to any written or verbal information which can be used to personally identify you that you have provided in your communication with us or when giving your consent unless you have given us permission to do so (e.g., showing your video).

Your Responses - What we will record:

a. The gathered movement and physiological (e.g., muscle activity) data from sensors, video/image, audio, and questionnaire and diary recordings of your activities, as described above, will be used for our analysis. We would further use examples from the sensor recordings of your activities and your responses to our questions, neither of which can be used to personally identify you, in scientific publications (including academic theses) and presentations.

b. Questionnaires data - Your responses to our questionnaires will be recorded in digital format either as online forms or other electronic documents, e.g. pdf forms.

c. Video/Audio data – We will video record the study to capture yours hand and arms movement. We will try to avoid to capture your face.

How we will use what we record:

- The data we record (letter, sensor data, questionnaire ratings and transcribed interview) will be used for analysis. Anonymized data will be shared with our collaborators UKRI Textile Circularity Centre (https://www.rca.ac.uk/research-innovation/research-centres/materials-science-research-centre/textiles-circularity-centre/) and related project (e.g. CX) (https://www.rca.ac.uk/research-innovation/research-centres/materials-science-research-centre/textiles-circularity-centre/) that the principal researcher Nadia Berthouze is part of.

- ADDITIONAL USE OF DATA THAT CAN BE USED TO IDENTIFY YOU: We will never disclose your name or contact details with the data gathered. We will not share the video or the audio outside our UCL research group unless you have given us written permission to do so.

- ADDITIONAL USE OF DATA THAT CANNOT BE USED TO IDENTIFY YOU If you give us permission, we will share anonymised data (sensor data, questionnaires responses), which CANNOT be used to identify you, with the wider research community, without your names or contact details included. This will further support advance in better understanding of movement and the design of related AI-technology.

7. What are the possible benefits of taking part?

As a thank you for your time, you will receive £15 as payment. There are no immediate benefits for those people participating in the project. It is hoped that this work will shape future research on movement and touch sensing

technology and technology to automatically detect affective experiences from movement and touch. We also hope our research will contribute to design technology that foster wellbeing and create a more sustainable and circular economy.

8. What if something goes wrong?

Extreme care will be taken in this research. However, if you wish to complain or have any concerns that are not addressed by the researcher, you should contact Prof Nadia Berthouze (nadia.berthouze@ucl.ac.uk) who is the Principal Researcher on the project. If you further feel that your complaint has not been handled to your satisfaction, you can contact the Chair of the UCL Research Ethics Committee (ethics@ucl.ac.uk).

9. Will my taking part in this project be kept confidential?

Your name and contact details will be kept strictly confidential. We would further only share DE-IDENTIFIED questionnaire, transcripts and sensor data with other researchers, and only if you give us permission to.

10. Limits to confidentiality

Confidentiality will be respected unless there are compelling and legitimate reasons for this to be breached. If this happens, we will inform you of any decisions that might limit your confidentiality.

11. What will happen to the results of the research project?

The findings of our analysis of the data collected from the participants of the research project will be published in reports and articles and presented at public engagement and research talk venues. You will be able to access academic publications of these findings on the project website: https://uclic.ucl.ac.uk/people/nadia-berthouze. You will not be identifiable in these publications and presentations. Your name and contact details will never be included in publications and presentations.

The questionnaire and sensor data we collect from you, which CANNOT be used to identify you, will be made open for use by other researchers, for the benefit of scientific and technology development; but only if you give us permission to do so in the consent form.

12. Local Data Protection Privacy Notice

Notice: The controller for this project will be University College London (UCL). The UCL Data Protection Officer provides oversight of UCL activities involving the processing of personal data, and can be contacted at data-protection@ucl.ac.uk

This 'local' privacy notice sets out the information that applies to this particular study. Further information on how UCL uses participant information can be found in our 'general privacy notice: https://www.ucl.ac.uk/legal-services/privacy/ucl-general-research-participant-privacy-notice

The categories of personal data used will be as follows:

- Name, Age, Gender, contact details
- Muscle and movement activity
- Video

The lawful basis that would be used to process your personal data will be performance of a task in the public interest. The lawful basis used to process special category personal data will be for scientific and historical research or statistical purposes.

Your personal data will be processed so long as it is required for the research project. If we are able to anonymise or pseudonymise the personal data you provide we will undertake this and will endeavour to minimise the processing of personal data wherever possible. If you give us permission to make open the data to the wider research community or use it in other research projects we are involved in, processing of the personal data will continue beyond the end of the research project.

If you are concerned about how your personal data is being processed, or if you would like to contact us about your rights, please contact UCL in the first instance at data-protection@ucl.ac.uk.

Thank you for reading this information sheet and for considering taking part in this research study.

A.2 Consent Form used in round 2

Information and Consent

AAA

INFORMATION SHEET

Thank you for your interest in our research project.
Please carefully read the Information Sheet attached below,
then proceed to complete the Consent Form below.

Attachment: Information Sheet.pdf (0.14 MB)

CONSENT FORM

Project Title: TCC: Affective sensing technology: The affective tactile language in clothing attachment

Department: University College London Interaction Centre

Researcher: Yuanze Gan yuanze.gan.20@ucl.ac.uk, Alice Sansoni, a.sansoni@ucl.ac.uk, Nihara Warawita nihara.warawita.21@ucl.ac.uk,

Principal Researcher: Prof Nadia Berthouze, nadia.berthouze@ucl.ac.uk

Data Protection Email: data-protection@ucl.ac.uk

This study has been approved by the UCL Interaction Centre Research Ethics Committee: UCLIC_2021_018_Berthouze_PE

Thank you for considering taking part in this research. If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you decide whether to join in. You will be given a copy of this Consent Form to keep and refer to at any time. Before the study starts, you will be able to ask further information during a video conference call and you will still have the option to opt out. Please note that if you answer No to some of the questions you may not be elegible for this study.

1) I confirm that I have read and understood the Information Sheet for the above study. I have had an opportunity to consider the information and what will be expected of me. I have also had the opportunity to ask questions which have been answered to my satisfaction.

* must provide value

- ○ Yes
- ○ No

2) I confirm that I understand the recruiting criteria and I also confirm to be at least 20 years old.

* must provide value

- ○ Yes
- ○ No

3) I consent to participate in the study. I understand that my personal information, if applicable, (name, age, address) will be used to contact me, send me any materials, or used for the purpose explained to me in the Information Sheet.

* must provide value

- ○ Yes
- ○ No

4) I understand that I will be audio and video recorded to enable accurate analysis of the data. I understand that my personal information, survey data (text question responses, think aloud), sensors data (physiological data and movement data), interview transcript, audio recordings will be

used for the purposes explained to me. I understand that according to data protection legislation, 'public task' will be the lawful basis for processing for my personal data and the lawful basis used to process any special category personal data will be for scientific and historical research or statistical purposes.

* must provide value

- ○ Yes
- ○ No

5) I understand that my participation is voluntary and that I am free to withdraw from the study at any time. I understand that if I decide to withdraw from the study, I can revoke my consent by signing a consent change form. I understand that I can also withdraw data I have provided, up till the 2nd day after the experiment session I took part in is completed, without giving a reason. If I choose to also withdraw my data, the data will no longer be used.

* must provide value

- ○ Yes
- ○ No

6) I am aware of who I should contact if I wish to lodge a complaint.

* must provide value

- ○ Yes
- ○ No

7) I understand that identifiable information collected will remain confidential and that all efforts will be made to ensure that I cannot be identified except where explicit consent is given below.

* must provide value

- ○ Yes
- ○ No

8) FURTHER USE OF MY DATA (Tick the boxes to indicate you agree with the related use of your data)

- ☐ I agree for my sensors data [body/hand movement or related physiological data], text question responses, interview transcriptions, which CANNOT be used to identify me, to be made open to other researchers and for future research or secondary analysis, to facilitate research and innovation.
- ☐ I agree for PHOTOS recorded from me (e.g., during the study) to be included in written publications used to disseminate the project findings. I understand that I could be recognised from such images and the audience may make copies of the image(s) and that the researcher will not have control over such copies.
- ☐ I agree for PHOTOS/VIDEOS/AUDIO recorded from me to be used in presentations used to disseminate the project findings. I understand that I could be recognised from such photos/videos/audio and the audience may record the presentation and that the researcher will not have control over such recordings.
- ☐ I agree for my non personal information (sensors data, text question responses, interview transcript, diary) to be used for secondary analysis in other studies that the researchers of this study are involved in, to facilitate research and innovation.
- ☐ I agree to be contacted to participate in follow up studies to this project, or in future studies of a similar nature. I understand that my name and contact details will not be shared with anyone who is not a member of this research team.
- ☐ I agree for PHOTOS/VIDEOS/AUDIO recorded from me to be shared with Alice Sansoni (University of Milano, Italy) and used in her thesis and related presentations.

9) Preferred Contact Details (email):

* must provide value

10) Full Name of Participant

* must provide value

11) Date

* must provide value

12) Signature

* must provide value

Submit

A.3 Order for round 2

Participant 1: PARTICIPANT ID 19

Cloth 3:

1st prop: Softness

2nd prop: Flexibility

3rd prop: Smoothness

4th prop: Thickness

5th prop: Warmth

Enjoyment

Cloth 2:

1st prop: Warmth

2nd prop: Thickness

3rd prop: Softness

4th prop: Smoothness

5th prop: Flexibility

Enjoyment

Cloth 4:

1st prop: Smoothness

2nd prop: Thickness

3rd prop: Flexibility

4th prop: Softness

5th prop: Warmth

Enjoyment

Cloth 6:

1st prop: Softness

2nd prop: Thickness

3rd prop: Flexibility

4th prop: Smoothness

5th prop: Warmth

Enjoyment

Cloth 5:

1st prop: Warmth

2nd prop: Softness

3rd prop: Smoothness

4th prop: Flexibility

5th prop: Thickness

Enjoyment

Cloth 1:

1st prop: Thickness

2nd prop: Flexibility

3rd prop: Warmth

4th prop: Smoothness

5th prop: Softness

Enjoyment

Participant 2: PARTICIPANT ID 22

Cloth 1:

1st prop: Softness

2nd prop: Warmth

3rd prop: Flexibility

4th prop: Thickness

5th prop: Smoothness

Enjoyment

Cloth 6:

1st prop: Softness

2nd prop: Warmth

3rd prop: Smoothness

4th prop: Flexibility

5th prop: Thickness

Enjoyment

Cloth 5:

1st prop: Softness

2nd prop: Smothness

3rd prop: Warmth

4th prop: Flexibility

5th prop: Thickness

Enjoyment

Cloth 2:

1st prop: Smoothness

2nd prop: Thickness

3rd prop: Smoothness

4th prop: Warmth

5th prop: Flexibility

Enjoyment

Cloth 4:

1st prop: Softness

2nd prop: Flexibility

3rd prop: Thickness

4th prop: Smoothness

5th prop: Warmth

Enjoyment

Cloth 3:

1st prop: Softness

2nd prop: Thickness

3rd prop: Flexibility

4th prop: Warmth

5th prop: Smoothness

Enjoyment

Participant 3: PARTICIPANT ID 23

Cloth 1:

1st prop: Thickness

2nd prop: Flexibility

3rd prop: Smoothness

4th prop: Warmth

5th prop: Softness

Enjoyment

Cloth 6:

1st prop: Softness

2nd prop: Flexibility

3rd prop: Smoothness

4th prop: Thickness

5th prop: Warmth

Enjoyment

Cloth 4:

1st prop: Thickness

2nd prop: Softness

3rd prop: Flexibility

4th prop: Warmth

5th prop: Smoothness

Enjoyment

Cloth 2:

1st prop: Warmth

2nd prop: Softness

3rd prop: Thickness

4th prop: Flexibility

5th prop: Smoothness

Enjoyment

Cloth 3:

1st prop: Warmth

2nd prop: Thickness

3rd prop: Softness

4th prop: Flexibility

5th prop: Smoothness

Enjoyment

Cloth 5:

1st prop: Flexibility

2nd prop: Smoothness

3rd prop: Softness

4th prop: Warmth

5th prop: Thickness

Enjoyment

Participant 4: PARTICIPANT ID 21

Cloth 4:

1st prop: Warmth

2nd prop: Softness

3rd prop: Thickness

4th prop: Smoothness

5th prop: Flexibility

Enjoyment

Cloth 6:

1st prop: Flexibility

2nd prop: Warmth

3rd prop: Softness

4th prop: Thickness

5th prop: Smoothness

Enjoyment

Cloth 1:

1st prop: Warmth

2nd prop: Smoothness

3rd prop: Flexibility

4th prop: Thickness

5th prop: Softness

Enjoyment

Cloth 5:

1st prop: Softness

2nd prop: Warmth

3rd prop: Thickness

4th prop: Flexibility

5th prop: Smoothness

Enjoyment

Cloth 3:

1st prop: Thickness

2nd prop: Warmth

3rd prop: Softness

4th prop: Smoothness

5th prop: Flexibility

Enjoyment

Cloth 2:

1st prop: Thickness

2nd prop: Flexibility

3rd prop: Smoothness

4th prop: Softness

5th prop: Warmth

Enjoyment

Participant 5: PARTICIPANT ID 25

Cloth 4:

1st prop: Thickness

2nd prop: Warmth

3rd prop: Flexibility

4th prop: Smoothness

5th prop: Softness

Enjoyment

Cloth 3:

1st prop: Smoothness

2nd prop: Warmth

3rd prop: Thickness

4th prop: Flexibility

5th prop: Softness

Enjoyment

Cloth 5:

1st prop: Softness

2nd prop: Flexibility

3rd prop: Thickness

4th prop: Smoothness

5th prop: Warmth

Enjoyment

Cloth 2:

1st prop: Flexibility

2nd prop: Softness

3rd prop: Smoothness

4th prop: Thickness

5th prop: Warmth

Enjoyment

Cloth 1:

1st prop: Flexibility

2nd prop: Warmth

3rd prop: Thickness

4th prop: Smoothness

5th prop: Softness

Enjoyment

Cloth 6:

1st prop: Smoothness

2nd prop: Warmth

3rd prop: Softness

4th prop: Flexibility

5th prop: Thickness

Enjoyment

Participant 6: PARTICIPANT ID 24

Cloth 5:

1st prop: Smoothness

2nd prop: Thickness

3rd prop: Flexibility

4th prop: Warmth

5th prop: Softness

Enjoyment

Cloth 2:

1st prop: Smoothness

2nd prop: Thickness

3rd prop: Softness

4th prop: Warmth

5th prop: Flexibility

Enjoyment

Cloth 6:

1st prop: Flexibility

2nd prop: Smoothness

3rd prop: Warmth

4th prop: Thickness

5th prop: Softness

Enjoyment

Cloth 4:

1st prop: Softness

2nd prop: Smoothness

3rd prop: Thickness

4th prop: Flexibility

5th prop: Warmth

Enjoyment

Cloth 1:

1st prop: Flexibility

2nd prop: Softness

3rd prop: Warmth

4th prop: Thickness

5th prop: Smoothness

Enjoyment

Cloth 3:

1st prop: Smoothness

2nd prop: Softness

3rd prop: Warmth

4th prop: Thickness

5th prop: Flexibility

Enjoyment