Underneath the Skin: An Analysis of YouTube Videos to Understand Insertable Device Interaction

Aida Komkaite
Human-Centered Comp.
Aalborg University
Aalborg, Denmark
a.komkaite@gmail.com

Liga Lavrinovica
Human-Cenetred Comp.
Aalborg University
Aalborg, Denmark
liigah@gmail.com

Maria Vraka
Human-Centered Comp.
Aalborg University
Aalborg, Denmark
mariavraka@outlook.com

Mikael B. Skov
Human-Centered Comp.
Aalborg University
Aalborg, Denmark
dubois@cs.aau.dk

ABSTRACT

During the last decade, people have started to experiment with insertable technology like RFID or NFC chips and use them for e.g. identification. However, little is known about how people in fact interact with and adapt insertables. We conducted a video analysis of 122 YouTube videos to gain insight into the interaction with the insertables. Second, we implemented an online survey to complement our data from the video analysis. Our findings show that there are many opportunities for interaction with insertables both for task-oriented and creative purposes. However, there are also multiple challenges and obstacles as well as side effects and health concerns. Our findings conclude that the current infrastructure is not ready to support the use of insertables yet, and we discuss implications of this.

CCS CONCEPTS

• Human-centered computing~Empirical studies in HCI

KEYWORDS

Insertables; in the body; NFC; RFID; interaction; hobbyist; YouTube; survey;

ACM Reference format:
Aida Komkaite, Liga Lavrinovica, Maria Vraka and Mikael B. Skov. 2019. Underneath the Skin: An Analysis of YouTube Videos to Understand Insertable Device Interaction. In *2019 CHI Conference on Human Factors in Computing Systems Proceedings (CHI 2019), May 4–9, 2019, Glasgow, Scotland, UK.* ACM, New York, NY, USA. Paper 214, 10 pages. https://doi.org/10.1145/3290605.3300444

CHI 2019, May 4–9, 2019, Glasgow, Scotland UK

ACM ISBN 978-1-4503-5970-2/19/05…$15.00
https://doi.org/10.1145/3290605.3300444

1 INTRODUCTION

We are witnessing a growing interest in technologies and devices that can be imbedded or implanted into our bodies for various interaction purposes. Since the 1960s, where the first pacemaker was implanted into a heart failure patient [20], a wide range of different medical implantable devices (IMDs) have been developed and introduced, for example implantable cardioverter defibrillators (ICDs), insulin pumps, cochlear implants, various diagnostic and monitoring devices. Such technologies typically improve well-being, health, and everyday opportunities for the involved patients. But implantables are typically prescribed by medical professionals, and patients do not usually choose themselves such implants.

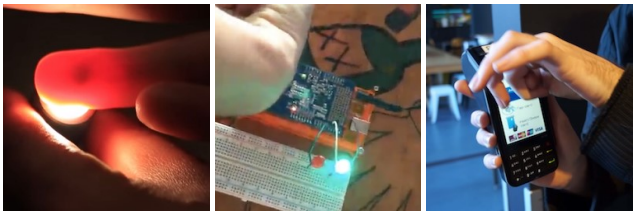


Figure 1. Examples of screenshots from our included YouTube videos showing an implanted magnet (left), experimentation (middle), and payment (right).

Recently, people have started to explore technology that is implanted in their bodies by choice. In this paper we will refer to these as insertables, as introduced by Heffernan et al. [13]. They explain that insertables are non-surgical devices and typically are implanted as a result of personal choice [15] as opposed to implantable devices that are used for medical purpose. A movement of so called "Hobbyists" [8] or "do-it-yourselfers" [9] or a multitude of other names people have given themselves, has emerged focused on inserting various devices under their skin. There is emerging interest in this type of technology within the HCI community as well. Heffernan et al. [14] conducted a study to investigate the motivation and reasons for getting insertables as well as categorizing the most common types of devices such as magnets, NFC

and RFID microchips and bespoke devices. Furthermore, prior research work has studied adjustment periods of getting an insertable, issues related to always availability [10, 15], but we still lack understandings on how people interact with insertables.

Our aim in this paper is to understand interaction with insertable devices including challenges and opportunities of these devices. Further, as the implantation and use of these devices is voluntary, we also study the relation between motivation and use. Inspired by previous studies on how people with physical disabilities are adopting touchscreen devices [1], we adapt two methods for understanding such interaction. First, we used YouTube videos as data source to achieve an understanding of interaction with insertable devices. Secondly, we did an online survey to complement the data from the analysis of the videos. From different Facebook groups on insertables, we collected 68 responses.

Our findings show that people with insertables primarily use their insertable device for identification and access, but we also found that several users have a playful and creative use of such devices. Further, some users are intrigued by the physical sensations, but also experience challenges related to health, security, or privacy. Our contribution in this paper is an in-depth study of insertable technology with the focus on understanding and characterizing interaction and the associated challenges and opportunities.

2 RELATED WORK

Insertable interaction is related to the field of wearable computing where focus is on how body technology can provide and support activities and interaction. E.g. Vega and Fuks [37] discuss body technologies and the body as a design platform, and they distinguish between on the body, next to the body, and inside the body. The latter is of focus in this paper, and we will discuss two kinds of inside the body technologies. First, we focus implantable devices and then we will move on to insertable devices which is especially relevant to our field of focus.

2.1 Inside the Body: Implantable Devices

There has been some interest in HCI community in implantable devices. Skov et al. [35] conducted a study with implantable cardioverter defibrillator (ICD) patients about monitoring, data collection, privacy and surveillance. Additionally, Denning et al. [6] explored patient views and values regarding their IMDs including safety and security. Homewood and Heyer [16] explored microchip based implantable contraceptive device. They focused on existing implantable contraceptives and designing an interface for possible future solution. However, research on implantable devices has been primarily focused on medical devices [2, 16]. Research has investigated benefits and limitations of monitoring patients long-term with ICDs [29] or implantable loop recorders [21]. In addition, others have such devices as a form of treatment to various illnesses [5].

Furthermore, psychology research on insertables has studied acceptance of technological implants and the factors that affect the decision to use them. Pelegrín-Borondo et al. [30] focused on implants used to increase human capacities, namely “insideables”. The authors developed a model that measures the acceptance of new technological products and found that positive emotions have the greatest impact. Other studies by Whited et al. [40] and Wong [42] investigated mental health of patients with ICDs. The studies focused on common psychological risks for ICD patients such as depression and anxiety. Some studies showed that there were various factors that were associated with depression in ICD patients for example older age, marital status, self-care dependence etc.

2.2 Inside the Body: Insertable Devices

Within HCI there have been some studies regarding insertables. According to Heffernan et al. [13] in the last 20 years people have been voluntarily inserting devices under their skin for other purposes than just medical, as for everyday convenience or to extend human capabilities.

People interested in modifying their bodies or insertable experimentation are a part of the transhumanism movement, which was introduced by More [25] in 1990. The focus of the movement is to facilitate the technological enhancement of individuals’ bodies, senses and intellect [7]. A subculture of transhumanism related to insertable technology is called “grinding” [22]. Grinders describe themselves as individuals practicing functional body modification in order to extend human capabilities and experiment with their bodies [41].

As previously mentioned, Heffernan et al. [13, 14] conducted extensive research on users with insertable devices on motivations. They uncovered various reasons why people decided to insert NFC and RFID microchips or magnets into their bodies. Some participants talked about sensory improvement, as magnets were used as a sensory aid for blind people. Another reason was accessibility and efficiency of everyday activities, such as unlocking doors

or launching apps. Another reason includes tracking health information such as body temperature. Also, some of the participants decided to get an insertable because they were interested in body modifications or saw these devices as the next big thing. Lastly, a reason for choosing to insert devices was being tired of wearables and insertables more convenient as they were "always available".

There has been a growing interest in RFID and NFC microchips as insertables in humans. Various research papers [8, 23, 32] studied these devices in depth. One of the papers focused on people's perception of RFID microchips for employee identification in the workplace [31] which revealed more negative than positive attitude. Another paper discussed potential situations in which the use of microchips was applied, e.g. e-payments and privacy [24]. There has also been interest on risks and concerns on insertables. Three broad categories have been identified regarding insertable devices - health risks, social stigma and ethical concerns [13, 14]. Health risks referred to the possibility of rejection or infection; social stigma referred to the perception of people being "different" while ethical issues stemmed from concerns of privacy and access. Heffernan et al. [14] argued that ethical concerns were not an issue with most current non-medical insertables as they were not location-tracked, however, this argument did not include technology that require active monitoring.

3 STUDY

The aim of this paper is to provide a richer understanding of interaction with insertable devices and thus, complement the Heffernan et al. study [14]. First, we conducted a digital ethnographic study of YouTube videos of people interacting with insertables. Second, we implemented an online survey to enrich our data and ensure scientific validity. In the search phase we searched for YouTube videos where people either talked about their insertables or where they interacted using their insertables. In the second phase we discarded videos that were commercial or did not provide any relevant data for our study. Finally, we coded the final set of videos focusing on the interaction between the user and the insertables. In the video analysis and the survey, we used terms like "implant" and "implantable technology" as the users themselves are using these terms for insertables. Therefore, we did not want to create confusion by using the new terminology.

3.1 YouTube as a Data Source

The rise of digital technologies has provided opportunities for ethnographic studies that allow for easier and different ways of collecting data, e.g. online questionnaires, social media sites, blogs and digital videos [27, 36]. As video sharing platforms have become increasingly popular, YouTube has become a rich ground for gathering data and many studies across multiple disciplines have previously used YouTube as a data source [1, 3, 12, 33, 39].

We chose to implement this method as according to Paay et al. [28] YouTube videos can provide new insights into interaction. In our case it was difficult to gain insights into the real life interaction with insertables, as this type of technology was rather novel at the time and the number of users was small. In addition, Jewitt, [18] state that analysis of video data can also help researchers due to the ability to re-visit the videos and share them. However, researchers might not get all the necessary information from the videos as it is not possible to expand on the topic as in face-to-face studies and important elements could be excluded from the video. Inspired by Anthony et al. [1], we implemented a survey to address uncertainties in the video analysis.

3.2 Part I: YouTube Video Analysis

As mentioned above, our video analysis was divided into three distinct phases.

Phase 1: Search. We chose the three most common non-medical insertable technologies, cf. Heffernan et al. [14] and combined them with additional keywords (e.g. biohackers, interaction, transhuman, hobbyist). As most of the keyword combinations yielded thousands of results, it was decided to stop searching for videos after most search results started to be irrelevant. Initially a total set of 166 relevant videos were found during February 25 - 26, 2018.

Phase 2: Filtering. In this phase we filtered out 44 videos due to either being 1) irrelevant if it was a duplicate (already included), 2) used a language we couldn't understand (not English), 3) was commercial for a product, or 4) focused on the process of implantation rather than interaction. This phase resulted in 122 videos.

Phase 3: Analysis. Our final data set consisted of 122 videos, and some videos had more than one person in them. In addition, some of the users had uploaded more than one video concerning insertables, therefore, our study had 101 unique users out of 122 videos. Most videos were uploaded in 2017 (19) and 2016 (39), while other years were 2015 (18), 2014 (18), 2013 (9), 2012 (4), 2011 (6),

2010 (2), 2009 (5), and 2007 (2). The average length of videos was 3.56 min (from 6 sec to 29.36 min). Interestingly, 117 out of 122 videos were positive, while only five included users with a negative opinion. The analysis was inspired by Anthony et al. [1]. First, we adapted their search procedure using various keywords. Secondly, we were inspired by the format of the dimension table from [1] and adjusted it to fit our study resulting in 13 dimensions (table 1).

Table 1. Dimensions of our video analysis (inspired by Anthony et al. [1])

Video characteristics: • Video Purpose • Video Emotion: negative or positive • Language
Device usage in video: • Type of implantable device(s): e.g., RFID, magnet, NFC • Number of devices • Location of the device(s): e.g., fingertip, top of the wrist, purlicue
User characteristics: • Frequency of use • Motivation for having the implant • Overall impression/opinion of having the implant (concerns, regrets etc.)
Type of interaction: • Context: e.g., home, vehicle, office, garage • What the implant is used for? • Use of external objects: e.g., smartphones, locks, metal • Opportunities and problems

Three authors of this paper coded eight randomly picked videos independently which was followed by a discussion to align perceptions and the analysis. Afterwards, the analysis was conducted by dividing the remaining videos between us and coding them independently.

3.3 Part II: Survey

After the video analysis we conducted an online survey to complement our findings. There was a number of aspects we were not able to explore, such as some of the users' motivations and experiences. For example, a surprisingly small number of users talked about why they decided to get an insertable device. Therefore, we explicitly asked the survey respondents to elaborate on this topic. In addition, we wanted to collect more information about what kind of problems people have with their insertables, or what were their predictions about the future of insertables. We decided to conduct Facebook user group survey instead of YouTube users as we strived for complementary data by potentially addressing other kinds of users. Therefore our Facebook users are not necessarily representative of the YouTube users in our study.

The survey was created via Google Forms and consisted of 16 questions, for example, "Have you experienced any problems while using your implant/s?", "Why did you get the implant/s?". The survey was posted on two Facebook groups dedicated to users of insertables - one group dedicated to RFID and NFC insertables and one group dedicated to magnets. In total we received 68 responses within 12 days, which were then coded using directed content analysis [17]. We used prefixed categories derived from the video analysis to code the responses.

4 FINDINGS

In this section we will report the main findings of our video analysis and the survey. First, we will report on the characteristics of people who have insertables, then we will present our main themes. The identified themes illustrate the interaction in the videos and they do not necessarily represent the primary purpose for the users more generally. As stated in the study section, we have a total of 122 videos and 101 unique users. When presenting the findings of the video analysis we refer to video uploaders as users and respondents when we present the survey findings.

As one aim of the study was to find out what kind of people were interested in insertables, we also focused on the user characteristics (primarily based on the survey). Our survey showed that 78% of the respondents were males and 19% were females. Overall many survey respondents were in their twenties (49%) and only two of the respondents (3%) were over 50. In addition, the survey results revealed that there were also a few respondents who were under 20 (7%). According to our survey, the majority of users got the insertables during 2017 (32%) and 2016 (19%). Except for one, all of the survey respondents still had their insertables. That respondent removed their insertable due to the device migrating and having to be removed (S34).

Regarding the insertables that the users had, most of the users reported having an NFC or magnet insertable as seen in Table 2. The numbers display the total amount of users of each type of technology and placement

combination. The numbers in the brackets represent data gathered in the survey. 38 users reported having RFID/NFC microchip, however, it was often unclear if the users had a chip with both of these technologies or they were uncertain of the type of insertable. The most common place for the RFID and NFC microchips was the purlicue (the space between the forefinger and the thumb) on either the left or the right hand, while the most common placement for the magnet insertables was in the fingers. The category "other" refers forearm, tragus, elbow, wrist, sternum and the side and top of the hand. According to our survey, half of the respondents used their insertables daily, while 21% of them only used it a few times every month.

Table 2. Placement and type of the insertables. The numbers show the total amount of users of each type of technology and placement combination whereas numbers in the brackets show data gathered from the survey.

	Insertable technology				
	NFC	**RFID**	**RFID/ NFC**	**Magnet**	**Total**
Purlicue	30 (7)	15 (3)	13 (14)	0 (0)	58 (24)
Finger	0 (3)	0 (0)	0 (1)	29 (9)	29 (13)
Palm	0 (0)	0 (0)	2 (0)	4 (0)	6 (0)
Other	2 (5)	1 (1)	0 (8)	0 (4)	3 (18)
Total	32 (15)	16 (4)	15 (23)	33 (13)	-

4.1 Access and Identification

Our analysis showed that in the majority of videos (73 out of 122), the primary purpose of the insertable interaction was for access and identification. The videos demonstrated users gaining access to applications, websites or contact information on smartphones, as well as using their insertable as means of identification. All 73 videos with this type of interaction were task-oriented and included the use of either RFID or NFC insertables.

Some users programmed their insertables via an application and stored various information e.g. text files and links as they saw their insertables as an opportunity to have an easier and faster way to share their personal information. Our survey confirmed this as 63% of respondents used their insertable to share information with other people. In V81 the user talked about letting others scan his insertable with their devices to access a website that presented his work. According to him, it was "*an original way to promote my work*". Other two users used their insertable as a way to transfer information from the insertable to other people's devices or vice versa. For example, in V78 the user demonstrated how he scanned his NFC chip with other people's devices, to transfer his business card to their device. In addition, in V85 the user showed how to access a website by scanning his NFC chip by any NFC-enabled smartphone (figure 2). In contrast, another user demonstrated how a person sent a written message from their device to the user's NFC chip (V94).

One of the most common uses of the insertables (43 videos and 35 unique users) was access with identification purposes in order to activate functions usually with their smartphones. This is also illustrated by the survey findings as 77% of all respondents used their insertables as a form of identification for similar purposes as the YouTube users.

Most identification interacted with either looked door, phones, or computers. In 28 videos the insertables were used to unlock or lock either a car door or a regular building door. For example, in V88, the user had placed an RFID reader on the inside of his car, next to the front door on the driver's side, and he scanned his chip by placing his hand on the outside of the same place as the reader, to unlock his car. In V54, the user followed the same steps, but he started the engine of the car as well (figure 2).

In the 28 videos in which the insertables were used for identification, users had to purchase and install extra hardware either next to the doors, in the cars or motorcycles, in order to use their insertables. The actions of opening a door required RFID or NFC readers, while starting a car or a motorcycle required some modifications to the ignition. In several videos the users showed the readers that they had installed in order to use their insertables. However, using the insertables in certain public surroundings did not require extra hardware as readers were installed. For example, one user (V33) explained that he got tired of using a key card for entering his university. With the help of the IT department he was able to switch from his student card to his NFC chip.

(a) (b) (c) (d)

Figure 2. Interaction for access and identification (a,b) and for creativity and playfulness (c,d). (a) a user with an RFID unlocks his phone; (b) a user with an NFC unlocks his car. Whereas for creativity and playfulness: (c) the user in V25 uses the digital drawing machine with her magnet insertable; (d) the user in V64 demonstrates using his magnet insertable to listen to music.

Second most common within identification was to unlock smartphones (8%) or to log in to computers (4%). Other less common uses involved using insertables to pay at a vending machine, boarding a plane, opening a road barrier or an emergency tag as well as paying with the insertable (3%). None of the videos demonstrated interactions between the insertables and other people. Due to the nature and the capabilities of the insertables, only RFID or NFC chips were used to identify the users while magnets did not serve this purpose in the analyzed videos. In most of the videos the insertables were used in a private context either at home or to interact with personal systems such as cars, phones or laptops. However, four videos showed interaction with public systems. Two videos demonstrated how insertables could open doors while another video showed an insertable used to interact with a vending machine, which was placed at work. Lastly, in the fourth video the user interacted with an RFID/NFC reader at airport in order to board a plane.

4.2 Playfulness and Creativity

Our findings showed that in almost half of the videos (49 videos and 38 unique users) the purpose of the interaction was quite different. In these videos the users used magnet insertables, which overall had a less purposeful interaction, unlike the more task-oriented interaction with RFID and NFC. In some cases, the decision of getting a magnet insertable was more spontaneous. For example, one user wanted to get a piercing, but that was not possible at that time, so she impulsively decided to get a magnet instead. As she stated: "*I told myself no, I will not leave without something new, then I was just talking a little bit and looked at magazines, and it was jumping from one topic to another and then I had a magnet in my finger*" (V73).

The majority of users used their magnets to pick up or play with metallic objects such as paper clips and metallic balls. In some videos, users played with compasses by using their magnet insertables to interfere with electromagnetic fields and demagnetize them. The magnets were also used to sense electromagnetic fields and more users described having a 6th sense. Survey findings showed that 25 out of 68 respondents used their insertables for this.

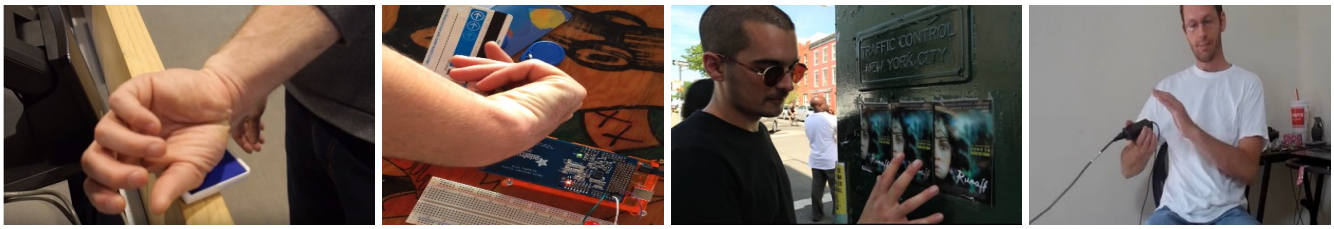
However, some users had creative uses of insertables. In V64, the user was listening to music through a magnet in his finger. He placed the finger with the magnet into a coil from a simple speaker, enabling him to listen to music whenever he puts his finger close to his ear (figure 2). When demonstrating this, , he stated: "*I can feel the rhythm in my finger, I can feel the bass, I can feel the hi-hats*".

Another user inserted magnets in his tragi (ie. small pointed eminences of the external ear) in order to have wireless headphones with him at all times (V104). Furthermore, one user used his magnet insertable to wipe magnetic strips on tickets and cards. Finally, in V25 the user built a system, which allowed her to draw digitally, using the magnet insertables in her fingers. The system she built consisted of different types of additional hardware that was used to build a magnet reader, which was able to sense electromagnetic fields. This reader was then connected to her computer. By moving her magnet over the reader, the movements were registered and illustrated on the computer screen as colorful drawing lines on a blank page (figure 2).

4.3 Challenges and Obstacles

We found 57 videos (47 unique users) illustrating different challenges and obstacles in the insertable interaction. These show that insertables is still underdeveloped field. The most common challenges present in the videos included: 1) lack of compatibility, 2) insertables being insufficient, 3) limited functionality and 4) unexpected interaction.

The first challenge was related to the lack of support from surrounding technology, which made the interaction



(a) (b) (c) (d)

Figure 3. Examples of awkward positioning (a,b) and physical sensation (c,d). For (a), a user scans his NFC insertable at an airport (V111); and (b) the user demonstrates his NFC chip on his self-made reader (V83). For (c) the user in V47 with magnet tries to sense electromagnetic fields; (d) the user in V100 with magnet senses electromagnetic fields near his AC/DC adaptor.

with insertables difficult. For example, one user said that RFID readers were designed to read from flat surfaces:

"NFC readers, (...), expect really a flat surface chip. The chip in my hand is cylindrical, it's in the glass container and it's underneath my skin. Getting the NFC reader physically to read the content of the chip is kind of difficult. I have to angle my hand in an uncomfortable way against the reader, even push my hand onto the reader, which makes it kind of uncomfortable and maybe unhygienic as well." (V113). This was an obstacle for several users. In the videos a total of nine users had to awkwardly position their hands for the reader to be able to read their insertables: "*It's awkward to hold my hand like this*" (V29) (figure 3). 15 respondents of the survey also confirmed that this was an issue for quite some users with insertables. In addition, other eight users demonstrated that they had to fiddle with their insertables or readjust the angles in order for the insertables to work with the readers. Also, in some videos it seemed to be necessary to have either direct skin contact or very close contact to be able to use the insertables.

Also, this issue included problems with interacting with other technologies, as three YouTube users and five survey respondents specifically talked about either not being able to have an MRI at all (magnets): "*It needs to be removed before I have an MRI just like any other metallic implant*" (V103) or their insertables having some effect on the MRI and, therefore, needing to be covered (RFID and NFC chips) as the user in V43 explained: "*If you are in an MRI machine, the only thing that will happen is that you get a slight attenuation of the picture, it's just more blurry*".

Secondly, in some videos the interaction with insertables was insufficient. Specifically, in 11 videos the interaction between the insertables and other technologies seemed to take more time than doing it without an insertable. Surprisingly, this was in contrast with the findings in the motivation theme, which is introduced later in the paper, as some users got the insertable to become more efficient. For example, one user used his NFC chip to board a plane and found that it took longer with his insertable: "*getting the NFC reader to read the content on the chip, takes much longer time than just reading the paper boarding pass or the boarding pass on your screen on the phone*" (V113). Some videos demonstrated the seeming inefficiency of using an insertable for mundane tasks, such as unlocking a smartphone as it took up to six seconds in some videos to finish the task. Not only did it take some time for the insertable to work, it also required some fiddling in some cases, which contributed to the slowness of the insertables.

Thirdly, we noticed some challenges related to the rather limited functionality of insertables. Two users mentioned that their insertable could only perform one function at a time and should be reprogrammed for other purposes. The user (V33) talked about how in a perfect world he would never have to reprogram his insertable but that he had to already do it a couple of times that day. He mentioned that when he went home he would set the insertable to only lock up, while at other times he would add his business card or a shopping list to the device based on his activities. The survey findings also illustrated this as six out of 68 respondents had reported that they wished the current insertables had more functionality as they were not that useful at that time. As S37 explained: "*It's a nice toy, but I want more functionality.*" Moreover, 17 out of 68 survey respondents did report that they inefficiency (slow or having to reprogram it frequently).

Some users talked about unexpected interaction with their insertables. For example, five users mentioned the need to be careful when experimenting with magnet insertables as one user in V100 advised to: "*be very careful dealing with electricity*" or strong magnets. Some users as well as survey respondents (5/68) also mentioned that their insertable set off shop alarms or could wipe the magnetic strips of tickets or cards. In addition, the

placement of the insertable also needed to be considered based on their activities or interests, as one user had to get her insertable in her right hand, because she was left handed and an artist. Thus, it was crucial to get the chip in the opposite hand:

"*I am left-handed, so I made sure to get it in my right hand (...) in the exact space that (the chip) is chipped in my hand is where my pen would sit so it would be a massive problem for me if I did get it in the other hand*" (V81).

4.4 Physical Sensations and Health Concerns

According to our video analysis, getting an insertable device had both anticipated and unanticipated physical sensations as a total of 19 videos (14 unique users) discussed these sensations. Further, a couple of users had concerns about health risks related to getting an insertable.

Physical sensations were most common in users who had a magnet insertable as 11 videos (nine unique users) and 37% survey respondents mentioned electromagnetic waves. They described the physical sensations as vibrations or buzzing when being close to metal objects, microwaves or electricity in general (figure 3). Eight users reported feeling more and being able to extend their human capabilities with three users in particular describing it as having a 6th sense. A user (V102) described this experience as "*seeing a new color*". Even though such sensations were weird at first, they described them as "*amazing*" and "*a wonderful experience*". Few users loved these new sensations so much as one of them (V47) said "*it enriches my everyday life and I'm experiencing joy*".

Not all physical sensations were anticipated for either the users or survey respondents. Two users with insertable RFID or NFC chips talked about disliking that their insertable was visible and they could feel it through the skin. Four users and 10 survey respondents reported feeling uncomfortable or having pain due to the insertables: "*My fingertip magnets can be uncomfortable while gripping something very hard*" (S29), while another survey respondent (S59) mentioned experiencing "*phantom itching*". One of the RFID chip users mentioned that he would feel pain if too much pressure would be put on his insertable, thus, making holding heavier objects sometimes uncomfortable. Likewise, in V62 one user of a magnet insertable mentioned that he felt "*uncomfortable around bigger magnets*", while another one mentioned discomfort when he was around microwaves.

In regard to health, two users discussed what should be considered when deciding to get an insertable. One of them talked about the case of having a cheap RFID/NFC chip, which might break inside the skin or transfer bacteria and cause infections. Another magnet user mentioned the chance of infection or the possibility of losing the magnet underneath the skin. One of the survey respondents actually experienced an infection problem: "*Removed the magnet because the coating of the magnet was dissolving overtime starting to cause a small infection, decided to remove it before it would cause more issues.*" (S22) The rest of the users were not worried or did not mention health concerns.

4.5 Practicality, Capabilities, and Self-Expression

In 27 videos (18 unique users) users explicitly talked about their motivation for getting an insertable device. In these videos we identified three main motivations for having an insertable, practical application, transhuman capabilities and self-expression. While the two former motivations were also identified and illustrated by Heffernan et al. [14], the self-expression complement their findings.

The first motivation for getting an insertable was due to practical application (eight videos and nine unique users, one video had two users). They decided to get an insertable because of efficiency and convenience. Users talked about the benefits of not carrying tags, keys and wallets anymore for various every day activities such as unlocking doors: "*I recently built this RFID system for my doors but didn't like to carry around a tag with me, so I got one injected into my hand*" (V5). Additionally, users enjoyed that most mobile phone functions were automated e.g. in V33 the users stated: *"(...) you can send automated SMS, turn on and off GPS etc."* making them faster and easier to complete.

The second motivation for getting an insertable was to extend human capabilities as nine users (six unique users) were interested in the transhumanism movement. In V47 the user stated "*(...) through the use of technology we can transcend the suffering in human condition*". Some of the users with magnet insertables said that they enjoyed having new abilities, for example, picking up small screws from a laptop. Another person with magnet insertables said: "*(...) you can tell which way is north, you can tell when something is magnetic*" (V102). For the survey respondents extending human capabilities was the most common motivation as the majority of respondents (47/68) got an insertable due to this reason. 60 survey respondents

reported that one reason for getting an insertable was to experiment with the technology.

The third motivation for getting an insertable was because in some videos (four unique users) users wanted to express themselves in a unique way. Some of them got an insertable because they wanted to feel "*cool*" (V62). Other users talked about wanting to be different or provocative: "*It's meant to be extreme or pointless or even provocative, thought inspiring (…) just something different*" (V91). However, the survey findings showed a significantly higher number of respondents (28 out of 68) who wanted to express themselves and be different.

4.6 Security and Privacy

Security and privacy are important aspects of insertable technology. Surprisingly, it was less of an issue in the analyzed videos. Security and privacy were addressed by four out of 101 users. Two of the users were not concerned about these issues. One of them mentioned in V48 that security is enhanced by RFID chips, as "*no one can start the engine [of his vehicle] without the chip*". The other user was not concerned about privacy issues as he explained that the NFC chip can be scanned and read only within a small range. He stated that he was only "*interested in investigating social and privacy issues*" (V95). Finally, only two users mentioned that they were concerned about security and ethical issues respectively.

The survey findings showed a similar trend in regard to security, privacy and ethical issues, as 88% of all responders were not concerned with the aforementioned issues. Some of the more common arguments included the limited range, the passiveness of the insertables, not storing private information in the insertables and the technology not being advanced enough as respondent S29 stated: "*tech has not advanced to the point where implants would be a viable means of privacy invasion yet*". However, several respondents did stress that security issues would become bigger in the future and would require more attention:

"*I think future cybernetic implants that are more complex than these will have to be designed with security in mind and to give the user control over their data.*" (S19)

The remaining respondents (7 out of 68) did have some concerns regarding security, privacy, or ethics. However, most respondents seemed to be concerned about these issues in general and not specifically for their insertables.

5 DISCUSSION

There has been a growing interest in insertables in recent years by both users and HCI researchers. But research on interaction with insertables is still in its infancy. Therefore, our aim was to investigate how users interact with their insertables and what challenges and opportunities did they face. We did a digital ethnographic study of YouTube videos and conducted an online survey. Whilst we achieved insight on interaction with insertables as one contribution of the paper, we identified a number of themes that constitute a second contribution of the paper. These are elaborated in the below sections.

5.1 Insertable Use and Interaction

Previous HCI research on insertables has mainly focused on why people are inserting these devices in their bodies [14] or what kind of devices are available and the most common uses for the insertables [8, 9, 10, 14]. E.g., some people would insert these devices for sensory improvement, as magnets can be used as sensory aid for visually impaired people. Also, some people would sometimes insert these devices for accessibility or everyday activity efficiency. This included unlocking doors or launching apps.

But our study further revealed interaction purposes and use for these insertable device, and in this way our work complements the work of other studies, e.g. Heffernan et al. [13, 14]. First, we identified two main interaction purposes: identification and access, as well as four related challenges and obstacles: lack of compatibility, inefficiency, limited functionality and unexpected interaction. Furthermore, we found that users were experiencing physical sensations, and some of them had health concerns. Finally, we looked into users' views and opinions on security and privacy.

Our study further indicated that insertable interaction is perhaps gradually growing, but also changing. Our YouTube video analysis revealed that the number of included videos grew every year indicating that insertables are becoming more common, or perhaps people just upload more videos. But more interestingly, while the types of used insertable devices seem stable (RFID, NFC, or magnets), we observed a change in interaction purpose with magnets going from simple sensorial use (early years) to more playful interaction during later years.

5.2 Embedding Insertables into Infrastructure

With our focus on interaction with insertables, our findings showed that there is a need for considering how to embody these devices into existing technological infrastructures and not only focus on embedding them into people's bodies.

Unlike medical implantable technology, infrastructure is not a natural component of insertables, and users need to find, modify, or build the external equipment themselves. We found that the infrastructure for this technology seems to be lacking at the moment. Our findings show that current technology is only partially ready to support insertables. Most of the challenges that the users in our video analysis and online survey have encountered seem to stem from the immaturity of the existing infrastructure. The users who use their insertables to interact with other technology need to utilize common readers that are meant for regular RFID and NFC tags as currently there is no possibility to purchase readers designated for the use of insertables. In some cases, the interaction with insertables is slow or results in having to position their hands awkwardly in order to complete the intended task with the insertable.

Even though most users have experienced problems with their insertables and that the current infrastructure is not yet ready to support the use of insertables, almost all respondents did answer that they had no regrets regarding their insertable. This also confirms the findings of a study by Heffernan et al. [14], who reported that there were no regrets from any participants, even in cases when the user's body rejected the insertable and had to be removed. This consistent positive attitude of the users could be due to various reasons, which could be a topic for further research. While the current users seem to be willing to handle the limitations of interaction with insertables, it seems unlikely that insertables would become commonly used without improvements in the current technology.

5.3 Ethical, Security, and Privacy

Security and privacy of implantable medical devices have been extensively researched over the years. The main risks related to the IMDs include confidentiality of the user data, integrity of data transmitted from the devices and availability of the device to function properly [4, 33]. These issues of ethics or security seem to be different for insertables for a number of reasons. First, insertables are not used for medical purposes and not used to store confidential and sensitive information about user's health or treatments. Further, the device is not used for any life-threatening situations. Also, insertable users can simply choose to remove their device if they want to. Previous research work [8, 32] has looked more specifically into security, privacy and ethical aspects of insertable technology. RFID chips in particular were found to have weak security measures and users should be aware of this issue. In contrast, users in our study did not have any concerns related to the current insertables.

Ethics regarding implantable medical devices are mainly focused on the question of removing these devices from the end-of-life patients [43, 19]. The matter of getting an IMD is not the focus of research as these devices serve a life-saving purpose. In contrast, the issue of ethics related to insertable technology is related to the decision of getting an insertable device. A study conducted in Japan [26] showed that even though young people are accepting of insertables, they are questioning the morality of this technology. On the contrary, ethics was not an issue for most users in our study, as they argued that getting an insertable was a voluntary action that was related to their own body.

5.4 Implications for Interaction Design

While insertable technology is still very new, our study shows that there is potential in this type of technology. Today most types of technology can be disabled at any time, e.g. one can turn off smartphones or wearables. Insertables, e.g. RFID, do not offer this opportunity to users yet. This could be an issue in the future, therefore we need to investigate how to deal with this and implications of this.

One promising future application could be the possibility of paying for goods and services everywhere and anywhere without credit cards. There are already some developments in this area, for example VivoKey, an insertable device that will "cryptographically merge the user's biological and digital identities", ensuring higher levels of security [38]. Our study also shows that people with insertables see great potential of this technology in medical applications. In particular, Heffernan et al. [14] concluded that monitoring biometric data from within a human's body could be one of the possible future applications of the insertable technology.

Our findings showed that in order to use the insertables efficiently, the current technological infrastructure need to be improved. Technology needs to support insertables and interact with them seamlessly. When designing technology for this purpose, the location,

range and other characteristics of the insertables need to be considered. Another aspect to be considered is that seamless interaction could potentially cause unwanted interaction. Pairing the insertables with more types of technological devices would provide more opportunities of use. Currently, the most popular device to pair the insertables is an Android phone. Expanding to more technological devices would develop more functionality and applications that the insertables could be paired with. In addition, expanding the storage of the insertables would allow for more than one function at the time, making the device more useful and efficient.

6 CONCLUSION

The aim of this study was to complement prior research on the use and interaction with insertables, as well as challenges and opportunities related to such interaction.

We conducted a study by applying digital ethnography to observe insertable interaction by analyzing YouTube videos, as well as an online survey to complement the video data. Our study showed that users interacted with insertables for access and identification and interaction for playfulness and creativity. The former purpose was task-oriented while the last purpose was for leisure and fun. However, our findings also show that multiple challenges exist such as limited functionality, lack of compatibility with infrastructure, inefficiency and unexpected interaction. In addition, interaction with insertables also has both side effects and security concerns related to the insertables.

There are many opportunities for future use of insertable technology, e.g. biometrics, payment. However, due to the insertable technology being very new, there is a need for extensive research into various aspects of the technology, such as security, privacy and ethics. Also, characteristics of users could be interesting as our findings showed a majority of young adults.

ACKNOWLEDGEMENTS

We would like to thank our survey respondents for their participation in our study and also several anonymous reviewers for comments in earlier drafts.

REFERENCES

[1] Anthony, L., Kim, Y. and Findlater, L. (2013). Analyzing user-generated youtube videos to understand touchscreen use by people with motor impairments. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 1223-1232. https://doi.org/10.1145/2470654.2466158

[2] Bhunia, S. and Young, D. J. (2012). Introduction to special issue on implantable electronics. ACM Journal on Emerging Technologies in Computing Systems (JETC), 8(2), 7. https://doi.org/10.1145/2180878.2180879

[3] Blythe, M. and Cairns, P. (2009). Critical methods and user generated content: the iPhone on YouTube. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 1467-1476. https://doi.org/10.1145/1518701.1518923

[4] Camara, C., Peris-Lopez, P. and Tapiador, J. E. (2015). Security and privacy issues in implantable medical devices: A comprehensive survey. Journal of biomedical informatics, 55, 272-289. https://doi.org/10.1016/j.jbi.2015.04.007

[5] Colquitt, J.L., Mendes, D., Clegg, A.J., Harris, P., Cooper, Picot, J. and Bryant, J. (2014). Implantable cardioverter defibrillators for the treatment of arrhythmias and cardiac resynchronisation therapy for the treatment of heart failure: systematic review and economic evaluation. Health Technology Assessment, 18(56), August, 1-560. https://doi.org/10.3310/hta18560

[6] Denning, T., Borning, A., Friedman, B., Gill, B. T., Kohno, T., and Maisel, W. H. (2010). Patients, pacemakers, and implantable defibrillators: Human values and security for wireless implantable medical devices. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 917-926. https://doi.org/10.1145/1753326.1753462

[7] Doede, B. (2009). Transhumanism, technology, and the future: posthumanity emerging or sub-humanity descending? Appraisal, 7(3).

[8] Foster, K. R. and Jaeger, J. (2007). RFID Inside. IEEE Spectrum, 44(3), March, 24-29. https://doi.org/10.1109/MSPEC.2007.323430

[9] Graafstra, A. (2007). "Hands On," IEEE Spectrum, 44(3), March, 18-23. https://doi.org/10.1109/MSPEC.2007.323420

[10] Graafstra, A., Michael, K., and Michael, M. G. (2010). Social-technical issues facing the humancentric RFID implantee sub-culture through the eyes of Amal Graafstra. Technology and Society (ISTAS), 2010 IEEE International Symposium on, 498-516. https://doi.org/10.1109/ISTAS.2010.5514602

[11] Halperin, D., Heydt-Benjamin, T. S., Fu, K., Kohno T. and Maisel, W. H. (2008). Security and Privacy for Implantable Medical Devices. IEEE Pervasive Computing, 7(1), 30-39. https://doi.org/10.1109/MPRV.2008.16

[12] Harley, D. and Fitzpatrick, G. (2009). Creating a conversational context through video blogging: A case study of Geriatric1927. Computers in Human Behavior, 25(3), 679-689. https://doi.org/10.1016/j.chb.2008.08.011

[13] Heffernan, K. J., Vetere F. and Chang, S. (2015). Insertables: I've got it under my skin. In Magazine Interactions, 23(1), 52-56. https://doi.org/10.1145/2843588

[14] Heffernan, K. J., Vetere, F. and Chang, S. (2016) You Put What, Where?: Hobbyist Use of Insertable Devices. Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16). ACM, New York, NY, USA, 1798-1809. https://doi.org/10.1145/2858036.2858392

[15] Heffernan, K. J., Vetere, F. and Chang, S. (2017). Towards insertables: Devices inside the human body. First Monday, 22(3), 6 March. http://dx.doi.org/10.5210/fm.v22i13.6214

[16] Homewood, S. and Heyer,C. (2017). Turned On / Turned Off: Speculating on the Microchip-based Contraceptive Implant. Proceedings of the 2017 Conference on Designing Interactive Systems (DIS '17). ACM, New York, NY, USA, 339-343. https://doi.org/10.1145/3064663.3064726

[17] Hsieh, H. F., and Shannon, S. E. (2005). Three approaches to qualitative content analysis. Qualitative health research, 15(9), 1277-1288. https://doi.org/10.1177/1049732305276687

[18] Jewitt, C. (2012) An Introduction to Using Video for Research. NCRM Working Paper. NCRM. (Unpublished).

[19] Kramer, D. B., Kesselheim A. S., Brock D. W. and Maisel W. H. (2010). Ethical and legal views of physicians regarding deactivation of cardiac implantable electrical devices: A quantitative assessment. Heart Rhythm, 7(11), 1537-1542. https://doi.org/10.1016/j.hrthm.2010.07.018

[20] Larsson, B., Elmqvist, H., Rydén, L. and Schüller, H. (2003). Lessons From the First Patient with an Implanted Pacemaker. Pacing and Clinical Electrophysiology, 26, 114-124. https://doi.org/10.1046/j.1460-9592.2003.00162.x

[21] Lee, R. and Mittal, S. (2017). Utility and limitations of long-term monitoring of atrial fibrillation using an implantable loop recorder. Heart Rhythm, 15(2), 287 - 295. https://doi.org/10.1016/j.hrthm.2017.09.009

[22] Lux, B. Bailey, P. and Reyes, C. (2017). Lead User Discovery through Netnography: Transhumanist Subcultures of Grinders and Biohackers. Engineering and Technology Management Student Projects. 1181. Retrieved from: https://pdxscholar.library.pdx.edu/etm_studentprojects/1181 Accessed 15 May 2018.

[23] Masters, A. and Michael, K. (2007). Lend me your arms: The use and implications of humancentric RFID. Electronic Commerce Research and Applications, 6(1), 29-39. https://doi.org/10.1016/j.elerap.2006.04.008

[24] Michael, K. (2016) RFID/NFC Implants for Bitcoin Transactions. IEEE Consumer Electronics Magazine, 5(3), 103-106. https://doi.org/10.1109/MCE.2016.2556900

[25] More, M. (1990). Transhumanism: Towards a futurist philosophy. Retrieved from: https://www.scribd.com/doc/257580713/Transhumanism-Toward-a-Futurist-Philosophy. Accessed on 25 of March 2018

[26] Murata, K., Adams, A. A., Fukuta, Y., Orito, Y., Arias-Oliva, M. and Pelegrin-Borondo, J. (2017). From a science fiction to reality: cyborg ethics in Japan. ACM SIGCAS Computers and Society. 47(3), September, 72-85. https://doi.org/10.1145/3144592.3144600

[27] Murthy, D. (2008). Digital ethnography: An examination of the use of new technologies for social research. Sociology, 42(5), 837-855. https://doi.org/10.1177%2F0038038508094565

[28] Paay, J., Kjeldskov, J., and Skov, M. B. (2015). Connecting in the Kitchen: An Empirical Study of Physical Interactions while Cooking Together at Home. Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing, 276-287. https://doi.org/10.1145/2675133.2675194

[29] Parthiban, N., Esterman, A., Mahajan,R., Twomey, D. J., Pathak, R. K., Lau, D. H., Roberts-Thomson, K. C., Young, G. D., Sanders, P. and Ganesan, A N. (2015). Remote Monitoring of Implantable Cardioverter-Defibrillators: A Systematic Review and Meta-Analysis of Clinical Outcomes. Journal of the American College of Cardiology. 65(24), 2591-2600. http://doi.org/10.1016/j.jacc.2015.04.029

[30] Pelegrín-Borondo, J., Reinares-Lara E. and Olarte-Pascual C. (2017). Assessing the acceptance of technological implants (the cyborg): Evidences and challenges. Computers in Human Behavior, 70, 104-112. https://doi.org/10.1016/j.chb.2016.12.063

[31] Perakslis, C., Michael, K., Michael M. G. and Gable R., (2014) Perceived barriers for implanting microchips in humans: A transnational study. 2014 IEEE Conference on Norbert Wiener in the 21st Century (21CW), Boston, MA, 1-8. https://doi.org/10.1109/NORBERT.2014.6893929

[32] Rotter, P. (2008). A Framework for Assessing RFID System Security and Privacy Risks. IEEE Pervasive Computing, 7(2), April, 70-77. https://doi.org/10.1109/MPRV.2008.22

[33] Sametinger, J., Rozenblit, J., Lysecky, R. and Ott, P. (2015). Security challenges for medical devices. Communications of the ACM, 58(4), 74-82. https://doi.org/10.1145/2667218

[34] Seo, W. and Jung, H. (2017). Exploring the Community of Blind or Visually Impaired People on YouTube. Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility, 371-372. https://doi.org/10.1145/3132525.3134801

[35] Skov, M. B., Johansen, P. G., Skov, C. S. and Lauberg, A. (2015) No News is Good News: Remote Monitoring of Implantable Cardioverter-Defibrillator Patients. Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15). ACM, New York, NY, USA, 827-836. https://doi.org/10.1145/2702123.2702192

[36] Varis, P. (2016). Digital ethnography. The Routledge handbook of language and digital communication, 55-68.

[37] Vega, K. and Fuks, H. (2016) Beauty Technology: Designing Seamless Interfaces for Wearable Computing. Springer International Publishing. https://doi.org/10.1007/978-3-319-15762-7

[38] VivoKey. Retrieved from: http://vivokey.com/learn-more.html Accessed on 30 May 2018.

[39] Weber, I., Garimella, V. R. K. and Borra, E. (2013, May). Inferring audience partisanship for youtube videos. Proceedings of the 22nd International Conference on World Wide Web, 43-44. https://doi.org/10.1145/2487788.2487803

[40] Whited, A., Sears, S.F., Cahill J. and Chelu, M.G. (2015.) Psychological Consultation for Patients with Implantable Cardioverter Defibrillator: Confounding Challenges of Cardiac Disease, Technology, and the Patient Experience. Alvarenga M., Byrne D. (eds) Handbook of Psychocardiology. Springer, Singapore. http://dx.doi.org/10.1007/978-981-4560-53-5_25-1

[41] Who We Are. Retrieved from: https://wiki.biohack.me/ Accessed on 15 May 2018.

[42] Wong, M. F. (2017). Factors associated with anxiety and depression among patients with implantable cardioverter defibrillator. JCN Clinical Nursing, 26(9-10), 1328-1337. http://doi.org/10.1111/jocn.13637

[43] Wu, E. B. (2007) The ethics of implantable devices. Journal of Medical Ethics, 33, 532-533. https://dx.doi.org/10.1136/jme.2006.019000