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Applications of Human Transponder Implants in Mobile Commerce

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Abstract

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Keywords

Human Transponder Implants, Radio-Frequency Identification (RFID), Mobile Commerce Applications

Disciplines

Physical Sciences and Mathematics

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ABSTRACT

When the ENIAC was launched in 1946, no one could ever have imagined that the giant thinking machine would one day find itself inside the *anthropos*. However the continuing quest for miniaturisation has made this possible: from luggables to wearables, and now, ultimately to implantable devices. This paper explores the potential for RFID transponder implants in humans for emerging mobile commerce applications. Three usability contexts have been defined to explore the applications which are projected to become mainstream service offerings. This paper is significant because it dispels the common misconception that microchip implants for humans are still some time away. In fact, the findings indicate that implants are set to make a universal entry into the marketplace due to the additional convenience and level of control they promise. Owing to this, a point of urgency is made at the conclusion of the paper that more cross-disciplinary discourse has to now take place to ensure that adequate considerations have been made for the longer term especially given the inherently controlling and invasive aspects of the technology.

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1. INTRODUCTION

The implanting of humans with transponders was once considered to be in the realm of science-fiction movies. Today however, the idea is being taken more seriously especially by governments seeking to put an end to acts of terrorism. Since the mid-1980s numerous patents on human applications of RF/ID transponders have been filed, and far from being just another novel invention, the technology exists with the potential to generate real commercial value. More recently, new service providers have targeted consumers, marketing human implants as the backbone of life-saving applications. Integration with location-based services (LBS) has also grown the application portfolio, particularly in the emergency sector. Other mobile commerce applications where transponders could be applied are in e-security, e-banking, and e-health. The wireless capability of RFID has been touted a more secure and effective alternative to identification than smart cards and biometrics. A transponder smaller in size than a grain of rice could provide the ultimate ID for citizens- injected in a given part of the body like the hand or head and present in the individual's subdermal layer of the skin. The implant would not only contain an ID number but could be multifunctional in nature, for instance with an ability to detect fever in an individual or take other physiological measures. The chip could also provide the ultimate monitoring device for people who are suffering from particular medical conditions such as Alzheimer's. Among other attributes, proponents of human implants point to its convenience and ubiquitous qualities. One does not need to manually carry a device and because it is implanted it cannot be misplaced or stolen. This paper explores the diverse range of mobile commerce applications for RFID transponder implants.

2. LITERATURE REVIEW

There is a plethora of literature available on RFID technology and its commercial application. Papers on technical issues [1], associated standards [2], and industry applications [3] abound. However, while much space is dedicated to contactless cards and tags, little space has been traditionally allotted to transponders in the literature. It is only now, given the rise of the Electronic Product Code (EPC) and the commensurate cost savings, that transponders have been given more attention by large corporations like Proctor & Gamble and Gillette. Among the industries however, where RFID has played a critical role since the mid-90s especially, is in farming [4], [5]. Animal identification has become a directive in most countries given the ongoing outbreaks of Bovine Spongiform Encephalopathy (BSE). In fact, much can be drawn from the research conducted into animal ID, in parallel to potential humancentric applications. Similar to tests conducted on dogs and chimpanzees in preparation for human space exploration, animals have been used as *guinea pigs* in preparation for the human transponder implant revolution. The process of identifying an individual animal in a herd would be no different to identifying a citizen in a given population. In fact the only operational human RFID implant company, Applied Digital Solutions, purchased an animal ID-only company (Destron Fearing) before launching its flagship product, the VeriChip.

2.1 The Context of Control

Substantial literature on humancentric control applications of RFID began in 1987 with Dr Daniel Man's patent of a homing device implant allowing authorities to pinpoint a person's exact location [6]. Following this, Hewkin [7] and Cambou [8] suggested that subminiature tags would be injected under human skin using a syringe to reduce problems such as fraud and to aid medical monitoring. More recently a patent specification for a 'Personal Tracking and Recovery System' [9] was registered to Paul Gargano et al. outlining an invention that can track and recover humans who are implanted with a RFID transponder. In beginning to turn thus theory into reality both Murray [10] and Eng [11] have documented the implantation of Richard Seelig. Seelig had one implant inserted in his hip and another in his arm in response to the September 11 tragedy of 2001. This sophisticated technology was employed to provide security and control over personal identification information. Similarly, Canadian artist Nancy Nisbet has implanted RFID microchips in her hands in order to "explore the relationship between identity and technology" [12]. Scheeres' article explains that Nisbet's experiment, albeit occurring in the name of art and not research, was primarily about the questioning and application of control in personal environments. Despite these descriptive analyses of current implementations, much literature in this field is of a speculative nature. Eng, for example, predicts that chips melded into children's bodies will be able to advise parents of a child's location, and alert guardians in situations where children are injured. Wakefield similarly predicts a future in which implanted tracking devices are common [13]. More importantly however, she propounds the notion of microchipping for national security and advises, "You can't get a better ID card than one you can put under the skin". Wakefield's proposal for an implantable national identification system gains credibility from Michael's work on "The Auto-ID Trajectory" [14]. This latter study presents a summation of the last forty years of change and offers a holistic view of the auto-ID industry where previously fragmented perspectives had been available [15].

2.2 The Context of Convenience

The first major documented experiment into the use of implantable RFID devices in humans revolved around convenience-related applications. *Pulse* [16], Brown [17] Sanchez-Klein [18], [19] and Witt [20] all give news reports on implantation of a RFID device into the arm of Kevin Warwick, Director of Cybernetics at the University of Reading. They define results of Warwick's research in terms of automation-having doors open, lights switch on and computers responding to the presence of the transponder. Warwick himself gives a review of the research in his article 'Cyborg 1.0', however this piece of literature is informally written and contains emotive descriptions of awesome experiences [21]. His article also contains proposals for his now-performed second RFID implant experiment, 'Cyborg 2.0', seeking to empower communication between humans with similarly implanted RFID devices [22]. Woolnaugh [23], Holden [24], and Vogel [25] all published accounts of the lead-up to Warwick's second experiment but all three are narrative descriptions of proposed events. Underhill documents the results of the experiment in his journalistic essay 'Merging Man and Machine' [26]. He notes that the outcome of the trial fell short of what Warwick predicted, leading to a critique of Warwick's visions as "fantasies". Though the commotion surrounding Warwick later died down, speculative fantasies did not with Eng proposing a future where credit card functionalities will be commonly contained in implanted RFID devices. The result would see commercial transactions and keeping track of your wallet made more convenient.

2.3 The Context of Care

After his Cyborg 1.0 experiment in 1998, Witt quoted Kevin Warwick as saying that with RFID implants he envisions paraplegics walking. Building incrementally on this notion has been the work of Kobetic, Triolo and Uhlir [27] who documented their findings of a 1 year study on a 41-year old paraplegic male who had an RFID controlled electrical simulation system implanted to deliver stimuli to his muscles. Though not allowing the mobility that Warwick predicted, results did include greater energy and overall fitness for the patient. In a similar report on research, Berger provides a discussion of Micro Electrical Mechanical Systems (MEMS) [28]. Berger notes that in studies, "MEMS has successfully measured the blood pressure in a healthy dog". Additional applications of chip implants in the context of care include: smart pills for drug delivery, biochips for diagnosis, cochlear implants, retina implants [29] and brain implants for persons suffering from Parkinson's. Unfortunately, the majority of further evidence is found only in journalistic news articles such as that of Murray [10]. For a detailed review of care applications of RFID see chapter 8 of Michael's PhD thesis (2003). Outside the sphere of research, much literature centres on the Jacobs family who were implanted with the commercial RFID device VeriChip in 2002. Murray [30], Black [31] and Grossman [32] all comment on the family of 'volunteers' and describe the medical reasons behind their implantation in a factual manner. Streitfeld [33] and Gengler [34] extend on this by reporting on the other five persons in the initial VeriChip trial, one of which, an Alzheimer's patient, was also chipped for medical, care-related purposes.

2.4 The Gap

Articles that do exist directly on the topic of human implants are generally too brief, subjective or too sensational to be considered useful. Most of these appear in journalistic type print, secular homepages, or fundamentalist web sites. The literature reviewed indicates that credible publications on this topic are scant. This paper is one of the first of its kind, signifying the entry of RFID implants for humans into the marketplace. It considers the major mobile commerce applications that could be targeted at a mass market population, including citizens, consumers and employees. The findings of the paper have been drawn from research conducted by Michael and Masters [35] in 2003. The applications described herein do not require the use of an additional device such as a cell phone, biometric print or card but may take advantage of technologies such as Global Positioning Systems (GPS). The significance of the paper has global implications for all people, especially given the possibility that widespread microchipping of humans may be introduced in the near future by governments.

3. METHODOLOGY

The primary focus for research involves several exploratory usability context analyses. These are qualitative in nature and are combined, to a lesser extent, with descriptive methods used to outline the nature of the application and establish scope of context. Further, to supplement the exploration, an interpretive analysis is applied followed by a final discussion on control, convenience and care applications. Similar to a case study, a usability context analysis: "investigates a contemporary phenomenon within its real life context when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used" [36]. It provides a process that "helps evaluation to reflect real-world usability accurately" [37].

4. CONTROL

Control is a dynamic notion, based upon knowledge of a desired outcome and, resultantly, upon the processing and distribution of information. Control can be defined as those situations in which human use of an implantable RFID transponder allows an implantee to have power over some aspect of their lives, or, alternately, allows a third party to have power over an implantee. The usability context analysis for control-related humancentric applications of RFID is divided into three main sub-contexts- security, management, and social controls.

4.1 Security Controls

4.1.1 Citizen Universal Lifetime Identifier

The most basic security application for humancentric RFID in the current state of development involves control over personal identification. Similar to an ID card, driver's license or passport, the RFID transponder contains information identifying the owner. The implant could be used as a citizen universal lifetime identifier (ULI) from birth. In theory, the limit to the amount of information stored is subject only to the storage capacity of the embedded microchip or associated database and, where implantation remains voluntary, to the imagination of the implantee. Further, being secured within the body, the loss of such identifying devices is near impossible even though, as has occurred in implanted herd animals, there are some concerns over possible dislodgement of the transponder. Keeping this in mind, the main usability drawback lies with reading the information. Implanted identification is useless if the information contained within the body is inaccessible.

4.1.2 Location-Based Services

The most prominent of the security-based applications involves GPS tracking to pinpoint the location of a third party. Control here exists in both the ability to find and in the ability to be found. A typical implementation sees the GPS component device worn, in the form of clothing or an accessory, by the person who is to be located. When combined with an implanted RFID transponder, a sophisticated level of identification is added to the application. Suitable GPS components are currently manufactured and sold as stand-alone products by several companies including the Digital Angel Corporation [38] and Whereify Wireless [39]. Devices such as these generally allow tracking accuracy to within a distance of several metres [40]. Variants are also available which incorporate "wander alerts", allowing a nominated caregiver to be notified whenever the wearer moves outside of pre-defined boundaries, and "fall-down alerts" which notify a nominated caregiver when the wearer has been down for one minute or more. In situations like these, the implanted RFID transponder becomes especially valuable as it allows for positive identification if the implantee is impaired, a child, an Alzheimer's patient or has been rendered unable to communicate. Many of the locator devices also provide a means for initiating emergency response.

4.2 Management Controls

4.2.1 Access

In terms of access controls, many smart-card access systems in common use today employ RFID technology to associate the cardholder with access permissions to particular locations. Replacing smart cards with RFID implants alters the form of the access pass but does not require great changes to verification systems. This is because identifying information stored on a RFID microchip in a smart card can be stored on an implanted transponder and readers can similarly be triggered when the transponder is nearby. Though such systems could plausibly be implemented anywhere as a replacement to key or card-based access, the application would have greatest value in 'mission critical' workplaces or for persons whose role hinges upon access to a particular location. Examples include power stations, water treatment plants, hospitals, airports, national defense and military facilities. The implanted access 'key' has the added benefit of being permanently attached to its owner with minimal risk of being lost or stolen.

4.2.2 Monitoring

Access provision translates easily into employee monitoring applications. In making the implanted RFID transponder the access pass to certain locations or resources, times of access can be recorded to ensure that the right people are in the right place at the right time. Control in this instance then moves away from ideals of permission and embraces the notion of supervision. Here, consideration needs to be given to the balance between recording employee work hours versus typical work behavioural patterns such as the number of times an employee uses the rest room or the coffee machine.

4.3 Social Controls

4.3.1 Enforcement

In the military transponders may serve as an alternative to dog tags. Using this technology, in addition to the standard name, rank and serial number, information ranging from allergies and dietary needs to shoe size can be stored. When linked to GPS tracking facilities a complex network of individuals can be monitored in training or during battle. With the location of troops being sent to military strategists in real-time, more informed tactical decisions could be made and relayed to soldiers using standard communications devices. Similarly, it allows for services like the rapid deployment of pastors to mortally wounded soldiers, for the location of prisoners-of-war (POWs) or identification of soldiers who have gone AWOL.

4.3.2 Punishment

Just as humancentric applications of RFID exist for law enforcement officers, so to can the technology have applications for people who have broken the law. Indeed, in 2002, 27 of 50 American states were using some form of satellite surveillance to monitor parolees [41]. Similar schemes have been used in Sweden since 1994 [42]. In the majority of cases, parolees wear wireless wrist or ankle bracelets and carry small boxes containing the vital tracking technology. Economic benefits exist as it is cheaper for parolees and minor offenders to be monitored or to serve their sentences from home. In Sweden for example, savings were estimated to be between 8 and 16 million US dollars for the 1997 calendar year. Social benefits are also present in that there is a level of certainty involved in identifying and monitoring so-called 'threats' to society even down to defining particular zonal regions as go/no go. Digital Angel for instance, has entered into a three-year pilot program with Los Angeles County parolees to monitor their movements using wearable devices [43].

4.3.3 Crime Prevention

Richard Seelig, one of the first persons to be implanted by VeriChip, believes that humancentric RFID is able to "function as a theft-proof, counterfeit-proof ID, like having a driver's license under your skin" [32]. One proposed application involves the implantation of airline crews to ensure that terrorists cannot infiltrate airports or gain access to airplane cockpits through means of disguise [44]. Another proposed application involves taking Infant Protection systems in existence at birthing centres and hospitals and internalising the RFID devices that are worn by newborns. Such usage would aid in the correct identification of those who do not have suitable means to identify themselves. Similarly, when connected with access alarms and building sensors, the technology could alert staff to the "unauthorized removal of children" [45]. This latter type of usage is equally applicable to childcare facilities and schools. This example leads to more morbid criminal scenarios. In South America for example, VeriChip "is being commercialised as a way to identify kidnapping victims who are drugged, unconscious or dead. In that market, the chip is being bundled with the… GPS device, Digital Angel, so police are able to track the abduction victim's location as well" [46]. One of the most vocal advocates for this application has been Antonio de Cunha Lima, a Brazilian politician.

5. CONVENIENCE

Convenience can be defined as those situations in which human use of an implantable RFID transponder increases the ease of performing a task for the implantee. The usability context analysis for convenience is divided into three main sub-contexts– assistance, financial services and interactivity.

5.1 Assistance

5.1.1 Automated Services

Automation is the repeated control of a process through technological means. Implied in the process is a relationship, the most common of which involves linking an implantee with appropriate data. Such information in convenience contexts can however be extended to encompass goods or physical objects with which the implantee has an association of ownership or bailment. Convenience transpires for both the implantee and for the greater system within which he or she may be a part because the technological association allows for ease of identification and location of object or owner. VeriChip, the American manufacturer of human-implantable RFID transponders, have developed VeriTag for use in travel. This device allows "personnel to link a VeriChip subscriber to his or her luggage… flight manifest logs and airline or law enforcement software databases" [47]. Further, at check-in, a bag is screened and considered 'cleared'. This status is used as the basis for loading and unloading passengers and luggage onto the aircraft. Convenience is provided for the implantee who receives greater assurance that they and their luggage will arrive at the correct destination, and also for the transport operator who is able to streamline processes using better identification and sorting measures.

5.1.2 Location-Based Services

Advancing the notion of timing, a period of movement leads to applications, that can locate an implantee or find an entity relative to them. This includes "find me", "find a friend" or "where am I", "where is the nearest" or "guide me to" solutions. Integrating RFID and GPS technologies with a geographic information systems (GIS) portal such as the Internet-based mapquest.com would allow users to find destinations based on their current GPS location and data regarding where they wish to be. Intelligent routing algorithms could also help persons to find the shortest path to their destination, by-passing areas of congestion and using recognized safe zone passageways. The nature of the application also lends itself toward roadside assistance and emergency services. In these cases, signals emitted by the GPS component are used to pinpoint the wearer's geographic location. The RFID transponder is used as an identifying link between the implantee as service subscriber, and the GPS device used to invoke the service. Convenience thus exists in the ability to be located and identified, especially when you do not know where you are.

5.2 Financial Services

5.2.1 Buying and Selling

Over the last few decades, world economies have advanced from the use of physical coins and bills into increasingly cashless societies. Arguably, contactless smart cards are now in a position where they can be implemented as a replacement for contact cards. In 2001 for example, Nokia tested the use of RFID in its 5100-series phone covers, allowing the mobile device to be used as a bank facility. RFID readers were placed at McDonalds drive-through restaurants in New York and the consumer was able to pay their bill by holding their mobile phone near a reader. The reader contacted a wireless banking network and payment was deducted from a credit or debit account. Of the trial, *Wired News* commented on system convenience by stating, "there is no dialing, no ATM, no fumbling for a wallet or dropped coins" [48]. Drawbacks exist with this particular non-humancentric application in the instance that a phone is stolen. It does however show the changing face of financial systems and as Ramo comments "in the not too distant future" money could be stored anywhere, as well as "on a chip implant under [the] skin" [49]. The possibilities for e-ticketing especially are endless, alleviating traffic congestion and queuing.

5.2.2 Banking

It is also feasible for humancentric RFID to eliminate the need to stand in line at a bank. Purely as a means of identification, the unique serial number or database access key stored on the RFID transponder can be used to prove identity for the purposes of opening an account or making a bank transaction. Due to the implanted nature of the identifier, the potentials for identity fraud are lessened making it a more secure and viable ID source. This presents convenience by reducing the need to gather paper-based identification and ensures that, should identification ever be further questioned, the same identification used to open the account can always be queried. This has similar benefits for Automatic Teller Machines (ATM's). When such intermediary transaction devices are fitted with RFID readers, RFID transponders have the ability to replace debit and credit cards. Thus, the convenience of current electronic banking services is available to carriers of humancentric RFID with the added benefit that forgetting your wallet is no longer an issue.

5.3 Interactivity

5.3.1 Interactive Locations

On August 24, 1998 Professor Kevin Warwick from the Department of Cybernetics at the University of Reading became the first human to be recorded as implanted with an RFID transponder. Using the transponder, Warwick was able to interact with the "intelligent" Cybernetics building that he worked in. Over the nine days he spent with the transponder implanted in his left arm, doors requiring smart card access automatically opened for Warwick. Lights activated when he entered a room and within his office, upon sensing the presence of the professor, Warwick's computer greeted him and gave a tally of email received. Warwick's experiment, labelled 'Project Cyborg 1.0', thus showed enormous promise for convenience-related humancentric applications of RFID [50]. The concept of such stand-alone applications expands easily into the development of an interactive home or office. With systems available to manage door, light and personal computer preferences based on transponder identification, triggering further climate and environmental changes is similarly feasible, especially considering non-humancentric versions of these applications (activated by wearable RFID) already exist [51].

5.3.2 Interactive Objects

RFID can control access to physical assets. Inherent in this idea of access control however, is the notion of interaction. For example vehicles of the future could have customised locks that use a RFID system, whereby doors will open automatically when the RFID reader identifies the transponder in a known driver or passenger. Convenience, in addition to the security benefits is therefore provided in timely access and keyless entry.

5.3.3 Communication

Given the success of interacting with inanimate locations and objects, the next step is to consider whether interaction between humans, i.e. person-to-person communication in different locations can be achieved through humancentric RFID devices. Such instantaneous communication would conveniently eliminate the need for intermediary devices like telephones or post. Answering this question was an aim in Project Cyborg 2.0 with Warwick writing beforehand, "We'd like to send movement and emotion signals from one person to the other, possibly via the Internet" [22]. Warwick's wife Irena was the second subject in the communications trial, being similarly fitted with an implant in her median nerve. Attempting to communicate through computer-mediated signals was met with limited success. When Irena clenched her fist for example, Professor Warwick received a shot of current through his left index finger [26]. Movement sensations were therefore successfully, even if primitively, transmitted. Broadcasting emotion and thought is a much harder task and, despite research at British Telecom into mind-implantable 'Soul Catcher' chips, given the results of Cyborg 2.0 such communicative technology is not feasible in the current state of development [52].

6. CARE

Care can be defined as any human use of an implantable RFID transponder that has a function associated with medicine or health. This may include applications that improve general well-being. The usability context analysis for care is divided into three main sub-contexts– medical, biomedical and therapeutic.

6.1 Medical

6.1.1 Medical Records

With implanted RFID transponders able to store identifying information or link to databases, the storage of medical records is perhaps the most obvious humancentric application of RFID. Similar to identification for control-related identification purposes, one of the primary benefits involves the RFID transponder being able to impart critical information when the human host is otherwise incapable of communicating. In this way, the application is "not much different in principle from devices… such as medic-alert bracelets" [34]. American corporation VeriChip markets their implantable RFID device for the purpose of medical identification. In April of 2002, the regulatory Food and Drug Administration (FDA) approved VeriChip for market-based distribution in the United States. The implantable RFID transponder was deemed not to be a regulated medical device and thereby became marketed as a multipurpose solution. In October of 2002 however, this was revised and the FDA ruled that while non-regulation was to continue over security, financial, identification and safety applications, VeriChip's healthcare applications were now subject to regulation in the United States.

Care-related humancentric RFID applications provide an unparalleled level of portability for patient medical records. Where many medical centres still keep paper-based record systems, the paper-trail problem inherent in changing doctors is significantly reduced. Implantable transponders also provide a reliable means of patient identification. Full benefit cannot be gained without an appropriate widespread infrastructure for usage however. Though the purpose of having medical data accessible through implanted RFID is to save lives in an emergency, this cannot be achieved if necessary reading equipment is not available to medical staff. The problem is especially great in the early days of application rollout, as the cost of readers may not be justified until the technology is considered mainstream. Also, as most proprietary readers are only capable of reading similarly branded transponders, questions regarding monopolies in the market and support for brand names arise.

6.1.2 Emergency Medical Response

The benefit of being able to convey medical data in emergency situations becomes clear when the implantee arrives at a medical facility where data can be read and used. Real value eventuates however, when the scope of the application is expanded and the implanted RFID transponder is able to alert medical facilities of an emergency. This eclipses current telephone-based emergency response services on two levels. First, RFID sensor technology intuits the emergency, seeks help and provides indicators of medical history if the implantee is unable to do so. Second, it provides emergency services with timely and accurate data. This reduces the emergency response call-taker's challenge of getting "an accurate location from the screams of disoriented, incoherent, or panicky callers" [53].

6.2 Biomedical

6.2.1 Biosensors

A biosensor is a device which "detects, records, and transmits information regarding a physiological change or the presence of various chemical or biological materials in the environment" [54]. It integrates biological and electronic components in order to produce quantitative results like the measurement of biological parameters, or qualitative results such as the recognition of a change in biological parameters. Of these parameters, thermal, electrochemical, mass and optical changes are the most common. When combined with humancentric RFID, biosensors acquire the functionality to transmit identifying information as to source, as well as the standard biological reading or result. The time savings alone in simultaneously gathering what are, by general rule, two different data sets are an obvious benefit. Flowing from this, a combined reading of biological source and biological measurement is less likely to encounter the human error associated with manually correlating data to a data source [55]. In the context of human care, this is especially important when for example, in a hospital scenario, patients need to be critically and accurately matched with their own biological statistics.

6.2.1.1 Temperature

Implantable transponders that allow for the measurement of body temperature have been used to monitor livestock for over a decade [5]. As such, implantable biosensor technology is not novel and its benefits, in terms of the data it procures, are well known. In addition, it gives a revolutionary new facet to human care by allowing internal temperature readings to be gained, post-implantation, through non-invasive means. The applications for this are wide and, as promoted by VeriChip, include: chemotherapy treatment management; chronic infection monitoring; organ transplantation treatment management; infertility management; postoperative monitoring; critical care monitoring; medication monitoring; and response to treatment evaluation.

6.2.1.2 Diabetes

An implantable transponder for use by diabetes sufferers has been proven in concept by biotechnology firm, M-Biotech. The transponder itself is a small glucose biosensor, consisting of a miniature pressure sensor and a glucose-sensitive hydrogel which swells “reversibly and to varying degrees” when changes occur in the glucose concentrations of surrounding body fluids [56]. Implanted in the abdominal region, a wireless alarm unit carried by the patient continually reads the data, monitoring critical glucose levels. Data can also be automatically transmitted to a caretaker. If glucose levels are measured outside of a predetermined “safe range” both patient and caretaker are alerted by an alarm.

6.3 Therapeutic

6.3.1 Monitoring of Implanted Devices

Implanted therapeutic devices are not new, having been used in humans for many years. Alongside the use of artificial joints for example, radical devices such as pacemakers have become commonplace. The combined use of RFID with these therapeutic devices however, has re-introduced some novelty to the remedial solution. This is because, while the therapeutic devices remain static in the body, the integration of RFID allows for interactive status readings and monitoring, through identification, of the medical device.

6.3.2 Treatment

There are very few proven applications of humancentric RFID in the treatment-related usability sub-context at current if one puts the well-documented cochlear implants [57] and smart pills aside [58]. Further, of those applications at the proof of concept stage, benefits to the user are generally gained via an improvement to the quality of living, and not a cure for disease or disability. With applications to restore sight to the blind and re-establish normal bladder function for patients with spinal injuries already in prototyped form however, some propose that real innovative benefit is only a matter of time. Arguably the technology for the applications already exists [59]. All that needs to be determined and proven is a correct implementation. Thus, feasibility is perhaps a matter of technological achievement and not technological advancement.

7. DISCUSSION

The usability context analyses for control, convenience and care were performed to determine the current state of development for humancentric applications of RFID. A broad range of applications were determined as feasible though many of these are untested and even less are in common or commercial usage. The choice of contexts stemmed from the emergence of separate themes within the literature, however the context analyses themselves showed much congruence between application areas. In all usability contexts for example, identification and monitoring are seen as core applications. For control, this functionality exists in security sub-contexts and in the management of access to locations and resources. For convenience, identification is necessary to provide assistance and monitoring is prevalent in supporting interactivity with locations and objects. Care, as the third context, requires identification for medical and therapeutic purposes and highlights the monitoring of biological parameters as basic functionality.

With standard identification and monitoring systems as a base for activity, it is logical that so many core humancentric applications of RFID are espoused as having a mass target market. Medical identification for example is not restricted to those with prior or ongoing illness because, as humans, we are all susceptible to accident or illness. Similarly, security and convenience are generic wants. Combined with the cross-correlation of core innovation outlined above, this mass-market appeal leaves the way open to combining applications across context areas. One potential combination would be in the area of transportation and driver welfare. Here the transponder of an implanted driver could be used for keyless passive entry (convenience), monitoring of health (care), location based services (convenience), roadside assistance (convenience) and, in terms of fleet management or commercial transportation, driver location (control) and monitoring (control).

Despite the outlined parallels and the potential creation of cross-contextual application systems, it is wrong to suggest that all context areas for humancentric RFID are equal in stature. Indeed, in the current state of development control appears as the dominant usability context. Though care can exist in third party control and medical convenience is present in care-related applications, it is control which filters through other contexts as a central tenet. In convenience-related applications for example, control exists in the power of automation and mass management, in the regulation of interactive environments and in the authority over interactive devices. Similarly, for care-related applications, medical identification is a derivative of identification for security purposes and the use of biosensors or therapeutic devices extends control over well-being. Accordingly, control is the dominating ‘umbrella’ theme that encompasses all contexts of humancentric RFID in the current state of development (see diagram 1).

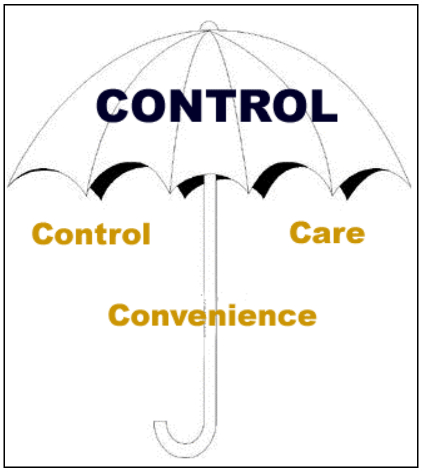

Diagram 1: Usability Context Analysis Themes

8. CONCLUSION

The results of the usability context analyses for humancentric applications of RFID showed a number of parallels between identified applications. Control however, is the dominant application area; with thematic influences appearing in convenience and care-related contexts. This influence ranges from control over self and identification, to third party control in location-based services. Humancentric applications of RFID are incrementally being built on the foundations of non-humancentric commercial and animal applications. Though the technology has been deemed feasible in both research and commercially approved contexts, the market for humancentric applications of RFID is still evolving. Initial adoption of the invasive technology has met with some success but any real assessment of the industry is prejudiced by the commercial monopoly of the VeriChip Corporation. Assessment of feasibility is also constrained by the limited research into long-term effects of the implanted technology and, where use in applications for herd animals has seen the transponders dislodged or attacked as a foreign body by the immune system, this presents a negative view of humancentric RFID. A real and present danger in the evolution of this cutting edge technology remains its alarming distance from critical and engaging cross-disciplinary discourse.

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