Paramedic-Focused Recommendations for the Design of a Medical Identification System

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Abstract

Historically, the design of medical identification jewelry has failed to consider the needs of paramedics, a major user group. Medical jewelry designs mimic contemporary jewelry styles and often feature irrelevant information, qualities that reduce their visibility and usefulness in an emergency. My thesis outlines a set of design recommendations, accompanied by a list of design requirements and a compliancy table, for medical jewelry that the user needs of paramedics.

The thesis draws upon open-ended interviews with paramedics from around the province of Ontario, to analyze the tacit and explicit knowledge that paramedics use when gathering information in medical emergencies. The analysis is used to develop a first iteration of design recommendations, which are presented to focus groups for feedback. Using a list of design requirements and a compliancy table formulated from my interview data, I judge three concepts to be especially promising, and have developed them as high-fidelity prototypes.

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Introduction

The design of medical identification jewelry has failed to keep pace with the dramatic changes that have characterized emergency medicine over the past fifty years. Ostensibly the first of its kind, the MedicAlert bracelet has retained a nearly identical functionality and appearance since its development from the mid-1950s to early 1960s. The physical design of the MedicAlert bracelet was created between 1953 and 1956 by the Collins family, in response to the teenaged Linda Collins' anaphylactic allergy to tetanus antitoxin; the young Ms. Collins conceived of a silver bracelet with her medical condition engraved on it while her father, a physician, designed the central plaque (MedicAlert Foundation, "History" 2013; MedicAlert UK, "Our History" 2013). Photos of the original MedicAlert bracelet and an early MedicAlert logo feature a Rod of Asclepius, an emblem of the medical profession, flanked by the words ''Medic Alert". A central plaque bearing this motif remains the hallmark of contemporary MedicAlert jewelry, and is closely mimicked by other medical jewelry brands, such as Universal Medical ID ("Bracelets" 2013) and Hope Paige ("Women Styles" 2013). MedicAlert's trademark patient database and telephone hotline were established internationally by 1964[1] (Stevenson 1964: 980).

In contrast, the first ambulance service in the world to provide civilian

1 These allow access to more complete patient information, and are advertised as the unique strength of MedicAlert products (MedicAlert Canada, "How MedicAlert Works" 2013; MedicAlert Foundation, "24/7 Emergency Response" 2013; MedicAlert UK, "Why MedicAlert" 2013).

pre-hospital medical care[2] did so in 1966, in Northern Ireland (Geddes 1986: 491). In Ontario[3], the first provincial charter of ambulance services was issued in 1968 (Newton 2013). It was not until 1972 that the United States Department of Transportation followed suit with a federal charter (Tangherlini 1998: 7). By this time, the MedicAlert Foundation had been operating for more than a decade[4].

It is clear that the functionality of MedicAlert jewelry (and, by extension, of the various brands that mimic it) was designed prior to the inception of paramedic services as we now know them, and therefore without consideration of what needs or preferences paramedics might have. It is hardly surprising, then, that contemporary medical jewelry does not make an effective tool for the contemporary paramedic. I became aware of a fundamental problem in the design of medical jewelry through anecdotal reports from acquaintances who are paramedics, doctors and MedicAlert wearers.

My interest in the design of medical identification jewelry originated with my own experiences as a lapsed wearer of a generic medical bracelet; when I got my bracelet, I had difficulty finding one that suited my personal style, and even once I had chosen one, I was never wholly satisfied with its appearance. I considered researching the design of medical jewelry in relation to the eyeglasses paradigm

2 Distinguished from basic resuscitation and first aid through the use of diagnostic and treatment equipment and/or pharmaceuticals.

3 In Canada, paramedic services are regulated at a provincial level. This paper focuses on paramedic services in Ontario.

4 The MedicAlert Foundation was founded in 1956 (MedicAlert Foundation, "History" 2013). The Canadian MedicAlert Foundation was founded in 1961 (MedicAlert Canada, "About MedicAlert" 2013).

(Pullin 2009), that is, taking a fashion approach to the design of medical devices. While I was considering this research direction, I spoke with an acquaintance who also has experience as a consumer of medical jewelry. Her son is diabetic and wears a MedicAlert bracelet. During my conversations with her, I found her to be less concerned with the bracelet's aesthetics than with its functionality. I found it especially noteworthy when she mentioned that there have been multiple occasions when her son has had a diabetic emergency, the paramedics have been called, and they have failed to check for his bracelet, resulting in a delay before he received treatment. This anecdote seemed to me to be indicative of a more urgent and fundamental problem than that of aesthetics: how valuable is it to have an attractive medical bracelet if it cannot fulfill its function of communicating information to medical personnel in an emergency?

In order to verify that the functionality of medical jewelry designs is indeed a problem, I spoke with several other acquaintances: a physician, a paramedic and a volunteer with St. John's Ambulance. Each of them expressed concerns about the visibility of the jewelry, while some also took issue with the legibility and relevance of the information on it. A subsequent search of the literature indicated that little has been written on the design of medical jewelry, the information-gathering practices of paramedics, or design for front-line medical workers. (There is a body of literature on the decision-making processes of paramedics, but this tends to interpret the decision process as value-laden, and therefore approaches the topic from a goal-

oriented perspective rather than a process-oriented one (Klein 1999, Wyatt 2003).)

I argue that paramedics constitute a major potential user group for medical identification jewelry. Given paramedics' increasing access to medical procedures and pharmaceuticals, it is increasingly likely that they may encounter a drug interaction or other adverse reaction while treating a patient. Furthermore, during my initial conversations, both the physician and the St. John's ambulance volunteer I spoke with stated that they are less likely to gather patient information or seek out medical jewelry than are paramedics. It is therefore relevant for paramedics to have information regarding certain drug regimens or medical conditions.

With this study, I seek to address the needs and preferences of paramedics with respect to medical identification jewelry. I attempt to ascertain the tacit and explicit knowledge practices used by paramedics as they gather information in emergencies, to develop a set of design recommendations that respond to these practices, and to produce a range of object prototypes that embody these recommendations, and which may be further developed toward practical application. To this end, I will address the following research questions:

1. What behaviours are performed by paramedics as they respond to an emergency? Specifically, what knowledge practices do paramedics enact when gathering patient information and making treatment decisions?
2. How can I balance completeness and relevance of patient information in a medical identification system?
3. What formal qualities of a medical identifier will allow me to store patient information completely and readably?
4. What formal qualities of a medical identifier will promote visibility?

In collecting and analyzing my data, I use social scientific methods drawn primarily from McCracken's *The Long Interview* (1988) and Luker's *Salsa Dancing into the Social Sciences* (2008). In developing my design recommendations, I have examined cognitive scientist Donald Norman's works on visceral, reflective, and especially behavioural design (2002, 2004), designer Graham Pullin's survey of (and challenge to) design for disability (2009), and readings on activity theory and activity-centered design (Kuutti 1996; Nardi 1996; Saffer 2010). The theoretical underpinnings of this project are supported by readings in the literature on tacit knowledge, specifically, anthropologist Harry Collin's *Tacit and Explicit Knowledge* (2010) and ethnographer Annemarie Mol's *The Body Multiple: Ontology in Medical Practice* (2002).

My goals for this project are twofold: to add to the body of literature on systems design for the medical field, and to guide the eventual development of a practical system of medical identification jewelry that is focused to the needs of paramedics. It should be noted that commercialization is outside the scope of this project; it would require, among other things, rigourous user-testing not only with paramedics but with wearers, which I have not sought to accomplish here. I have instead chosen to make this a focused study of the knowledge practices of paramedics as they relate to medical identification jewelry.

Based on my research, I recommend that a paramedic-centered medical identification system should use simple visual motifs that are familiar to paramedics'

daily practice, and that are already associated with information or with urgency. Furthermore, my design solutions avoid the use of technological strategies, such as digital storage of data, as Canadian paramedics' tacit practices are strongly biased toward analog devices. Finally, I recommend that the information architecture for a medical jewelry system should separate patient information into three categories defined by the sequence of events that occur during prehospital care. Moreover, this information architecture necessitates the use of three formally distinct identifiers within the system, each of whose information status is determined by its location on the patient's body.

From the results of my focus groups, I found three initial design concepts to be promising: the hospital band concept – a bracelet that mimics the form of hospital identification bracelets, the EKG band concept – a simple band marked around its outer circumference with a characteristic electrocardiogram (EKG) wave, and the pill motif – a red-and-white pill-shaped pendant in which information is stored using one of several possible methods. However, the revisions required of the pill motif proved to be impractical.

I revised the hospital and EKG band concepts in order to accommodate my recommendations regarding the system's tiered information architecture. Ultimately, I recommend the creation of a pendant and a wallet card, both of which prominently feature the EKG wave motif that is present on the revised hospital band and the EKG band. I recommend the development of these four designs as

high-fidelity prototypes.

Theoretical Framework

Choosing a Methodology

As mentioned previously, a preliminary problem I have identified in current medical jewelry designs is that they seem to be easily overlooked by emergency medical personnel. This suggests that, for whatever reason, the use of these devices is extraneous to the normal practices the personnel follow when responding to an emergency. In responding to this problem from a design perspective, I am essentially seeking to modify the actions of paramedics – that is, their information-gathering behaviour – through the introduction of a tool – my design recommendations. Thus, this study is situated within the realm of activity theory. Activity theory is a descriptive framework for the analysis of human action, including decision-making processes and the use of tools. Activity theory posits that human activity is mediated by the use of tools, be they physical or conceptual (Nardi 1996). This artefact-centered viewpoint is conducive to research for design, and it is therefore unsurprising that activity theory has been adopted as a framework for interaction studies (Kuutti 1996) and adapted into a design methodology. This methodology is called activity-centered design (ACD), and it is the primary approach used by this study.

ACD is in many ways similar to the better-known user-centered design (UCD). Both firmly advocate user research and take what Norman calls a "behavioural" approach to design that responds to the thought processes and actions

of users, rather than to their emotions (2004). The distinguishing feature of ACD is that it focuses on users' behaviours, including their use of tools, as they seek to accomplish a specific task or set of tasks. (UCD, on the other hand, focuses on users' thoughts and beliefs about what they need from a system (Saffer 2010: 36).) Like UCD, ACD may use participant interviews and observation, prototyping, and user-testing, but it seeks information specifically about the behaviours a user performs when participating in the activity of interest[5]. Whereas UCD seeks to design for the needs of the user, ACD seeks to design for the parameters of the task(s) (Norman 2005). This study seeks to respond to a set of tasks[6] that are sufficiently well-defined that they may act as design constraints (Chi 2005); ACD is therefore an appropriate methodology.

Activity-Centered Design and Tacit Knowledge

ACD's use of behaviour to parametrize designs parallels Wittgenstein's assertion that meaning is use (2001): within the context of the design process, analysis of scenarios on the basis of their enactments defines the meaning of a scenario as its enactment(s). Crucially for this study, this approach offers a way of accessing tacit knowledge, which, by its nature, should not normally be accessible

5 Per designer Dan Saffer (2010: 37), activities are the scenarios in which a person participates, and they are made up of actions and decisions. This terminology may be confusing, as Collins and Kusch define behaviours as "what observers see people doing", while actions encompass behaviours plus intentions (1998: 32) - Collins and Kusch's 'actions' are equivalent to Saffer's 'activities'. To minimize confusion, I will use only the terms behaviours and activities, as they are intended by their respective authors.

6 The tasks are those that comprise the activity of gathering patient information.

through typical user research methods such as interviews or focus groups.

Returning to my design problem, how to incorporate medical jewelry into the information-gathering behaviours of paramedics, I will have to address the various routines used by paramedics as they respond to emergencies. The word "routines" in this case refers to sequences of behaviours that a paramedic performs unconsciously while at her job. These may include formalized frameworks learned through training, to which the paramedic has become habituated or, more revealingly, behaviours developed through practical experience that may supercede formal procedures, such as the privileging of certain types or sources of information, or the bypassing of diagnostic steps deemed irrelevant in a given situation (Leeming 2012). The unconscious character of 'routine', as it used above, resembles philosopher Michael Polanyi's seminal conception of tacit knowledge, which he summarized with the statement "we can know more than we can tell" (Polanyi 1966)[7] . Furthermore, the experiential, professional nature of some of the routines in which I am interested suggests a substantial role for what Collins refers to as "collective embedding of knowledge" (2010: 148).

Both the formalized and experiential routines I describe above can be expected to resist explication, and an activity-focused approach to their study can therefore be expected to produce better results. Formalized routines belong to Collins' category of somatic-limit tacit knowledge. Both their unconscious nature

7 A popular, though by no means definitive example of tacit knowledge is the knowledge of how to ride a bike: it is certainly knowledge, but it cannot be fully and practically articulated (Collins 2010: 99-103).

and their incidence through repetition situate these routines within the "expert" stage of the Dreyfus model of skill acquisition, as outlined by Collins. Citing the Dreyfus model's example of driving a familiar journey, as well as the case of skilled copy typists, Collins points out that humans execute certain skills most efficiently when they do so unconsciously (2010: 102-104). Of course, skills that are best executed unconsciously are unlikely subjects for conscious reflection: observing a participant, or interviewing a participant in detail about a sequence of behaviours and subsequently analyzing those behaviours is much more likely to produce insights about these unconscious skills.

Experiential routines may be defined by their dependence on context: the procedures that are most important in one emergency situation will not be the same as in another. This context-dependence designates experiential routines as instances of collective tacit knowledge. Collins argues that in situations involving experiential knowledge, the decision to execute an action is dependent upon such complex and often informal cues, that this must be a case of tacit knowledge (2010: 120-124). He further argues that while in theory one might create a lookup table containing (or even simply memorize) all possible combinations of social cues with the correct responses for a certain type of behavior, this would lack the capacity for evolution that is common to all social conventions. Therefore, this tacit knowledge cannot be stored within artefacts or even within the individual, but instead must be housed within society as a collective (2010: 124-132). Thus, experiential routines

must resist explication. However, Collins posits that, "collective tacit knowledge is, to a large extent, located in the language of the collectivity" (2010: 136), and goes on to state that outsiders can therefore gain access to collective tacit knowledge by participating in the language of the collectivity. This assertion is crucial to my study, as it supports the use of a linguistic approach to gain understanding of a practice. This suggests that the use of open-ended, long-form interviews is an effective strategy to gain an activity-centered perspective on paramedics' use of medical identification jewelry.

Collins supports his position by noting that the acquisition of "practical understanding"[8] through linguistic immersion is a prerequisite for many characteristics of practice. He cites the elaborate sterilization procedures undergone by surgeons and operating room nurses as a practice whose meaning is contained within the language of germ theory (2011: 272). (Since practices are distinguished by their meanings[9] and, per Collins, meaning is stored in language (2010: 25-31), it follows that practices may be contained within language).

Collins' linguistic approach is supported by Mol's ethnographic study of medical ontology, which focuses on linguistic study of practices as a strategy both for spotlighting the lived reality of disease and for overcoming the tendency of

8 Collins defines practical understanding as "the ability to make practical judgments" (2011: 273).

9 Practices are polimorphic in that they require different actions to be carried out in response to different environmental conditions (for example, the different treatments a paramedic must administer in response to patients presenting with different symptoms). The judgment of what action to perform is guided by collective tacit knowledge, which is meaning-laden.

clinical medicine to rely on embedded knowledge[10] (2002: 11-15). She particularly advocates interacting with patients and doctors as if each were "his own ethnographer" (2002: 15). By allowing the researcher to learn about the practices that are enacted over the course of a disease, this strategy provides her with insight into the tacit knowledge processes that are executed in the clinic.

It is important to consider how my analysis of my interview data may be guided by Collin's model of methodological interactionalism. In this respect, the most crucial aspect of his theory is the definition of the collective as the unit of analysis. As mentioned earlier, Collins asserts that language and, by extension practices, are contained within the collectivity. This suggests that my analysis should focus on the commonalities among the data from my various interviews, in order to draw from the language of the collective of my participants, and gain an understanding of paramedic practice in Ontario.

Specific Design Strategies

Although he identifies mainly with UCD, Norman's writings on behavioural design are also highly relevant to ACD. The ultimate goal of an activity-centered study is, after all, to design recommendations that guide a specific behaviour. In order to produce "precise" behaviours through design, Norman prescribes four approaches (2002: 54-62):

1. Store information about the required behaviour "in the world," that is, in the

10 This is a term used by Young to describe knowledge that "cannot be deduced from people's talk" (1981: 317-335). It is a synonym for tacit knowledge.

designed object;
2. Minimize the precision of memory required of the user;
3. Provide physical constraints to possible behaviours;
4. Provide semantic constraints to possible behaviours.

The first approach may involve labeling functional elements of a design. It may also mean exploiting the design's affordances – the clues provided by its appearance about its function. Norman provides the example of a door panel with a large, flat plate, which affords the notion that one should push the door to open it (2002: 87-92).

In the case of a medical identification system, the first strategy could be employed by labeling the designed object with text indicating that it stores medical information. However, as Norman notes, reliance on the first strategy will constrain the efficiency with which the paramedic may come to use the device, since relying on external cues to complete a task can be slow and inefficient (2002: 56). This is in fact the same observation made by Collins with respect to somatic-limit tacit knowledge (2010: 101, 104). More importantly, the inclusion of such cues in a medical identification system cannot logically induce the desired behaviour (the checking of the system), since in order to perceive them the paramedic must already be interacting with the system. Essentially, these cues intervene at the wrong point in the action process; per Norman's Seven Stages of Action[11], they intervene between at some point between the formation of intention and the specification of

11 1) Perceiving the state of the world; 2) Interpreting the state of the world; 3) Evaluating our interpretations of the world and the outcome of previous actions; 4) Forming the goal; 5) Forming the intention; 6) Specifying an action; 7) Executing the action (Norman 2002: 47-48).

an action, whereas they need to intervene between the perception of the world and the interpretation of the world.

An alternative to storing information "in the world" is to store it "in the head". Training someone in the actions required for correct use of a system will increase their speed and efficiency, as well as decreasing the mental effort needed when completing the actions (Norman 2002: 56). As stated above, this is an effective strategy for developing habitual routines.

Norman's second strategy for guiding precise behaviour through design is to minimize the precision of knowledge required of the user. In the case of this study, I could seek to make all objects in the system substantially visually distinct from structurally similar but unrelated objects. For example, in creating pieces of medical jewelry, I could attempt to distinguish them from other commercial jewelry. This would minimize the level of knowledge needed by the paramedic in order to recognize these objects. This strategy is potentially useful, as it intervenes between the paramedic's perception and interpretation of the world.

Physical constraints limit the possible actions a user can take within a system. Norman offers as an example the vertical slot in a lock. This constraint forces the user to orient the key vertically to insert it into a lock, improving the user's odds of inserting the key correctly. In this study, a physical constraint might be imposed by designing medical jewelry to be worn over typical examination or drug administration sites. This would force the paramedic to handle (and hopefully

read) the object before proceeding with examination and treatment. In this case, the intervention should be effective since it contributes to the paramedic's perception of the world[12].

Finally, semantic constraints can be used to define the meaning of a situation and thereby guide the user's actions. In effect, they are agents of collective tacit knowledge. Norman identifies two major categories of semantic constraint: cultural constraints, which exploit cultural conventions, and logical constraints, which establish a logical relationship between the designed interface and its real-world referents. Returning to the example of the lock and-key, a cultural constraint might require the key to be inserted into the lock ridged-side-up to function, thus exploiting the convention that keys are typically inserted into locks ridged-side-up. Logical constraints are typified by well-designed switch panels, on which the spatial arrangement of switches mimics the arrangement of the lights they control (Norman 2002: 86). In the case of a medical identification system, cultural constraints might be employed through the use of emergency medical symbols or visual motifs common to emergency medical practice. Similar to the above-proposed physical constraint, a logical constraint could entail medical jewelry designed to be worn at the sites of probable emergent symptoms. Once again, these devices intervene between the perception and intervention stages of the paramedic's action. However, it should be

12 It may appear as though this intervention takes place between the intention and execution stages, and it does in the case of the external examination/treatment action. However, in the case of the 'medical system checking' action that I desire, the intrusive presence of the object contributes to a re-perception of the world, which includes the medical identification system.

noted that, because of the polymorphic character of medical emergencies, the latter intervention would be difficult, if not impossible to implement to practical effect.

Norman notes a final, practical strategy that designers may use to guide precise behaviour: standardization. In a sense, standardization seeks to develop and implement novel sets of cultural conventions. Because these conventions are novel, they require training on the part of the user; however, once they have been learned, they take on the role of cultural constraints and can help the user to construct meaning for any system in which they are used correctly. Norman recommends that standardization be used only when the other four strategies cannot be adequately deployed (2002). Given the challenges posed by medical polymorphism, and my stated goal of cultivating a specific behaviour within my user group, I include standardization among my design considerations.

Methodology

This study primarily employs an activity-centered design methodology, and also borrows from user-centered design. The activity-centered approach that I have used focuses on the behaviours of the target user group as they undertake specific activities to which the project seeks to respond (Saffer 2010: 35-37). I have collected data through open-ended interviews and focus groups, which has allowed me to ascertain information about how my participants prioritize certain behaviours.

Due to the speculative nature of this project, I defined the target user group in response to a broad initial design problem that I had found through anecdotal evidence: that of ineffective communication by existing medical identification systems, such as medical identification jewelry and medications lists. I determined that out of two possible end-user groups, emergency medical personnel (EMPs) and patients, the former, which includes paramedics and emergency-department physicians, was the most likely to engage with the information content of these systems and was therefore the appropriate target group for the project. In order to conduct interviews and focus groups with paramedics and other medical professionals, I obtained ethics clearance from the OCAD University Research Ethics Board (approval number 2012-17) and the Centennial College Research Ethics Board (file number 147).

The project's first data collection stage involved learning about the

information-gathering practices used by EMPs when responding to medical emergencies. Because such practices are based as much in tacit knowledge as they are in explicit knowledge (Collins 2010), it was necessary to develop an understanding of the information-gathering process not only insofar as it can be described by its practitioners, but also with respect to how the practitioners think through and about it. In particular, it was important to determine how practitioners prioritize and classify patient information, in order to create recommendations for the information architecture of the proposed system. It was also necessary to ascertain what behaviours paramedics perform when seeking patient information, so as to design a form that will complement their existing practices.

In order to accomplish this, I conducted a series of semi-structured long-form interviews with fourteen paramedics from five emergency medical services across Ontario. The services with which I worked serve a range of demographics, including large and small urban centers, suburban, rural and seasonal populations, and highway traffic (Table 1). The interviews were conducted either one-on-one or in small groups of up to seven participants. They adhered to the protocols prescribed by McCracken (1988) and echoed by Luker (2008), specifically, approaching the interview as a conversation directed mainly by the participants, and using interview questions primarily to create a sense of comfort and to guide the conversation when it lagged or diverged too far from the research topic. As recommended by McCracken (1988) and Luker (2008), I analyzed the data by performing multiple close

readings of interview transcripts to ascertain major themes within each interview, and to correlate these themes among different interviews to gain a sense of what considerations are most relevant to the problem of communication in medical identification systems. I also conducted a literature review of the medical directives and training materials used by paramedics in Ontario, in order to obtain information about specific procedures, and to compare the intellectual and experiential components of prehospital care.

Table 1.
The names and locations of emergency medical services that participated in my user interviews

Service	Base Locations
Kawartha Lakes	Bobcaygeon Coboconk Fenelon Falls Lindsay Oakwood
Middlesex-London	London Middlesex County
Oneida	Oneida First Nation
Toronto	Toronto
Waterloo	Baden Cambridge Kitchener St. Jacobs Waterloo

I used the findings from my interviews and literature review to develop a first iteration of my design recommendations. Based on these recommendations, I developed a set of six representative design concepts with different approaches to visibility, recognizability and information storage. I presented these concepts in a series of focus groups for project participants.

Focus group participants included four of the paramedics who participated

in the initial interviews, as well as five paramedic students. These participants once again represented a range of service demographics (Table 2). Furthermore, the participants were of different ages and at different stages in their careers; the most experienced participant has been a practicing paramedic for twenty years, and the least experienced participants are completing their first year of paramedic training. Age, time of certification, and location of service were expected to influence participants' perspectives on the use of technology. Therefore, variability in these demographics was important to ensure the sample was not artificially skewed for or against digital approaches.

Table 2.
The names and locations of emergency medical services that participated in my focus groups

Service	Locations
Centennial College	Toronto
Oneida	Oneida First Nation
Toronto	Toronto

Feedback was obtained through participant-guided interviews and focus groups in which participants were provided with illustrations, orthographic drawings, and explanations of the designs. Participants were asked to share their thoughts and preferences regarding the prospective usefulness and practicality of the various features, as well as any other features they might like to see.

From the focus groups, three design concepts were found to be particularly successful. These three concepts were modified and evaluated in response to the feedback obtained. One concept was ultimately rejected, while the other two were

further adapted in response to my initial recommendations regarding the system's information architecture. The two successful concepts were developed into high-fidelity prototypes, using materials and fabrication processes similar to those likely to be used in manufacturing the final products. The prototype stage necessitated materials and technology research in order to determine the physical and practical limitations of the various components and processes under consideration. This research was conducted through analysis of manufacturers' data sheets as well as consultation with production studios.

Key Research Findings

My research indicates that paramedics are a major user group for medical identification jewelry. Among the emergency medical personnel whom I interviewed, paramedics are the only ones who reported noticing medical jewelry. In fact, emergency department physicians noted that hospital staff rely on paramedics to report the presence of medical jewelry. Furthermore, several paramedics stated that medical jewelry has the potential to be useful in situations where patients are unresponsive, uncommunicative, or have a language barrier. In spite of this, however, most paramedic participants stated that they rarely see or use medical identification jewelry in practice. They attributed this to a range of reasons, most commonly, not finding the jewelry useful in its current form, not seeing or noticing it, not having the time to examine it, and a relative scarcity of patients who actually wear it.

The most common complaint made by participants concerned the dearth of relevant medical information on medical identifiers. This may be due in part to medical identifiers' reliance on patient reporting[13]; most participants commented that this is often inaccurate, incomplete, irrelevant, or some combination of the three. Another likely factor is the absence of any clear standard of what constitutes

13 It may appear as though this intervention takes place between the intention and execution stages, and it does in the case of the external examination/treatment action. However, in the case of the 'medical system checking' action that I desire, the intrusive presence of the object contributes to a re-perception of the world, which includes the medical identification system.

relevance in the context of a medical emergency. For example, glaucoma[14] is listed in the *Compendium of Pharmaceuticals and Specialties* (Canadian Pharmacists' Association 2011) as a contraindication for four paramedic-administered drugs (and several other emergency-relevant drugs), and it is listed as a relevant condition by a major medical identifier brand (Universal Medical ID, "Frequent Questions" 2013). However, one participant referred to glaucoma specifically as a condition that is irrelevant for inclusion on a medical identifier. Even more perplexing are medical conditions such as diabetes mellitus[15] and hypertension, which can have severe, systemic consequences that may contribute to medical emergencies, but can also be quickly and easily tested for by paramedics. It is unclear how useful it is to list such conditions on medical jewelry. (This ambivalence was reflected in participants' comments: most felt that diabetes should be included on medical identifiers, but one pointed out the potential redundance of doing so.)

My findings suggest that the problem of patient reporting could be addressed by transferring the burden of reporting to physicians. This could be expected to eliminate the inaccuracies and incompleteness that arise when patients misunderstand, or do not know the terminology of their medical histories. However, without clear and rational guidelines surrounding what information to include on medical jewelry, it is likely that physicians will also recommend the inclusion of

14 Glaucoma is a condition in which the optic nerve is damaged, often as a result of increased fluid pressure within the eye.

15 The condition that is popularly known as 'diabetes', in which the patient's body has a dysfunctional response, resulting in cells' poor uptake of glucose from the bloodstream.

irrelevant information or fail to recommend the inclusion of relevant information[16]. Thus, it is necessary to develop a set of practice-based criteria for determining the potential usefulness of patient information in a medical emergency.

During my first-round interviews, I found that emergency medical personnel are most interested in medical conditions or past procedures that may have some bearing on a patient's emergent condition, as well as in allergies, conditions or medications that contraindicate the use of drugs that are commonly administered prior to a patient's admission to the hospital. In order to identify relevant contraindications, I identified ten categories of drugs likely to be administered during pre-hospital or emergency department care; I then identified the members of the categories and their respective contraindications as listed in the *Compendium of Pharmaceuticals and Specialties* (Canadian Pharmacists' Association 2011), and three pharmaceutical smartphone applications ("Clinician's Pocket Drug Reference" 2013, "Epocrates" 2013, "Micromedex Drug Interactions" 2013). Some of these contraindications were ones that my participants had specifically mentioned as examples of common irrelevant information they receive (for example, anticoagulant therapy as a contraindication for receiving acetylsalicylic acid, or glaucoma as a contraindication for receiving epinephrine). I therefore filtered the list so that it included only interactions that are life-threatening or potentially life-threatening.

16 Physician Jerome Groopman (2009) provides a good examination of the wide variability among physicians' interpretations of and responses to indeterminate data is well-addressed.

In order to determine at what points during the course of pre-hospital care a paramedic may need access to patient information, I storyboarded[17] an edge case involving an unresponsive medical patient with unstable vital signs, no family or friends present, and no emergency contact information available (Appendix A). I found three stages at which access to information is vital. Prior to commencement of stabilizing algorithms, the paramedic should have information about any medical conditions or current medications that contraindicate prospective life-saving treatments. After stabilizing the patient and before administering any secondary treatments, the paramedic should be informed about contraindications to any other paramedic-administered medications, as well as about any major medical histories that may contribute to emergent symptoms[18]. Finally, once the paramedic has administered or initiated all necessary pre-hospital treatments, she should, time permitting, obtain information about any contraindications to common emergency department treatments, such as general anaesthetics, psychotropics, and antibiotics[19].

Concerns with the information content of medical identification jewelry

17 Storyboarding is a common design method for analyzing the requirements of a system by profiling the steps a user will take to complete a task of interest.

18 To provide a clear guideline as to what constitutes a 'major' medical history, I will consider as major any procedure or condition described in the chapters on medical emergencies in Mosby's Paramedic Textbook (Sanders 2007).

19 These drug categories were suggested by an emergency-department pharmacist who works with the University Health Network. She noted that anaesthetics and anti-psychotics may be administered quickly if a patient requires surgery or is very volatile. She suggested that antibiotics are relevant in emergency-department practice as they must be administered very quickly if a patient is suspected of sepsis (a life-threatening systemic inflammatory state induced by severe infection).

are one of two major problems reported by paramedics. The other is the lack of visibility and recognizability of current designs. Participants most frequently attributed this to the stylistic similarity of medical identification jewelry and conventional commercial jewelry: watches and delicate chains on bracelets were mentioned as design elements that are particularly challenging to identify as distinctly medical. Medical jewelry's mimicry of commercial jewelry is likely a manifestation of the 'discreet' approach described by Pullin (2010). He notes that designs 'for disability,' such as hearing aids, prostheses and, formerly, eyeglasses, are often rendered in pink plastic that is meant to mimic Caucasian skin, thus reducing their visibility. Similarly, as reported by my participants, a cursory glance at a contemporary medical bracelet reveals only an ID bracelet, a watch or a nylon wristband. However, the practical conditions of pre-hospital medical care render discreet medical jewelry ineffective.

During my interviews, several paramedics stated that they frequently do not have time to explicitly check for hidden identifiers. Every paramedic also noted that rather than spend a substantial amount of time searching for information from a specific source, a paramedic will gather information throughout her environment. Because paramedics are not accustomed to searching for information from any one source, a medical identifier must be both obvious and immediately accessible. With respect to the obviousness of medical identification designs, one participant went so far as to request, "flashing lights, disco balls, strobe lighting…[or] really

bright colours;" his partner noted that this comment was only half in jest. Another participant pointed out that the simple bands or chains used on many bracelet styles can be problematic, as they give no indication of the object's medical status and, once again, there is little time to turn the bracelet around and check. This participant suggested the use of colour or identifiable symbols on the band or chain, which would improve the object's recognizability from all angles. Participants also expressed a preference for standardization of the location and appearance of a medical identifier system. This issue is once again linked to medical jewelry's mimicry of commercial jewelry. Participants noted that uncommon medical identifiers such as anklets or tattoos may often go unrecognized.

A final major theme that emerged from my interviews is the need for immediacy in medical identification systems. Participants acknowledged that any system that requires additional steps is unlikely to be used in an emergency situation. This requirement in particular reflects poorly on the use of wallet cards and, in some cases, necklaces. The primary concerns about wallet cards were that patients may not always have such identifiers on or close to their person, and that paramedics are sometimes reticent to search a patient's pockets or possessions. One participant also mentioned that purses and other personal possessions are often not collected immediately from the scene of an accident, increasing the chance that devices like wallet cards or key fobs might not be found. With respect to necklaces, opinions were more mixed: some participants felt these are effective because they

are likely to be noticed in critical emergencies, wherein a paramedic will quickly obtain access to an unstable patient's chest. Other participants felt that in the majority of emergencies, a necklace will be relatively non-visible and inaccessible as it may be buried under a patient's shirt, whereas paramedics are likely to come into contact with bracelets while shaking a patient's hand or checking her pulse.

In addition to task-related design considerations, it is also necessary to consider human factors. Of particular importance is the size and appearance of any text that is present on recommended designs. Participants noted that the small text currently used on most medical jewelry designs is often not readable, especially for paramedics who are farsighted, or responding to night-time calls. In order to improve readability, text should be rendered according to human factors guidelines such as the United States Federal Aviation Administration Human Factors Criteria for Displays (Ahlstrom and Kudrick 2007: 5-14).

I have summarized those of my key research findings that apply to the formal and information design of medical jewelry systems in a requirements list, in Table 3. This list can be used to develop a set of compliancy tables for the evaluation of design recommendations for medical jewelry.

Table 3.
Specifications required for medical jewelry designs to successfully address paramedics' needs

Recommendation	Requirements
Visibility	Use attention-getting design elements
Recognizable	Use design elements that are distinct from commercial jewelry, and/or distinctly medical; use distinct elements around the chain or band to improve 360-degree recognizability
Accessibility	Require minimal steps between recognition of device and accessing of patient information
Readable	Any text elements follow accessibility guidelines such as those listed in the United States Federal Aviation Administration's Human Factors Criteria for Displays (Ahlstrom and Kudrick 2007).
Relevance of information	Include only information about severe or potentially fatal contraindications and hypersensitivities to emergency-relevant drugs and therapies
Three-tier information architecture	Display information relevant to life support drugs and therapies, non-life support paramedic-administered drugs and therapies, and pre-admission hospital-administered drugs and therapies on visually and geographically distinct devices

Initial Design Recommendations

Approaches to Information Storage

In addition to the design considerations that emerged from my interviews, my recommendations must account for the way(s) in which the proposed system will store information. My major goals with respect to encoding information in my designs are to maximize the amount of information that can be stored and to maximize the size of the stored text in order to improve its readability. Ultimately, both of these concerns come down to a matter of space; I need to maximize the space available for storing information. Two approaches to this problem emerged from my interviews: digital and analogue.

In researching digital options, I sought technologies that are very compact, that are suited for the storage of text strings longer than one hundred characters, and from which data can be retrieved with a minimum of steps. Technology use often necessitated a trade-off between form and function, due to structural and functional constraints imposed by various technologies, and concerns about wearability.

The most compact option that I identified is a low frequency, passive glass radio-frequency identification (RFID) tag[20]. In order to allow for entry and

20 RFID technology allows contact-free reading of information that is stored on a tag. This requires the use of a specialized RFID reader. In the case of a passive RFID tag, the reader emits a radio-frequency field that actives an integrated circuit within the tag, causing the tag to broadcast the stored information back to the reader, once again via radio-frequency modulation of the electromagnetic field (Chawla and Ha 2007). This modulation occurs via backscattering, a phenomenon in which incident waves are reflected in multiple directions after encountering an irregularity in the transmission medium. Low-frequency RFID tags operate at frequencies on the order of 102 Hz.

editing of patient information, I specifically sought read/write-type (RW) tags. The most practical option that I found offers 2048 bits of memory, with physical dimensions of 2.12x2.12x10 millimeters (RFID Canada, "LF Glass Tags" 2013). This should allow for encoding of 255 characters of ASCII text (Barcode Technology Solutions n. d.; ID Automation 2013), which should be sufficient for a patient's medical information in most cases[21]. The tag's small size makes it ideal for incorporation into a piece of jewelry and its shape matches the oblong form of a medicine capsule. I conceived of a pill-shaped pendant, depicted in Figure 1, as a container for this tag. Despite its strengths, RFID technology is limited in that a specialized reader is required to both read and write tags; implementing an RFID-based system would require emergency medical services to supply every ambulance with an RFID reader. This is unlikely to happen in the near future due to budgetary concerns, as well as the many levels of government by which such a development would need to be approved.

Figure 1.
RFID pill concept

An emerging alternative to RFID is near-field communication (NFC). In terms of physical function, NFC is actually a variant of passive RFID wherein

21 Based on his experiences, one participant estimated that the upper threshold for essential information on a patient history would include "eight medications, five or six different histories [medical conditions or procedures], two allergies." I created a list for a prototypical patient who fit these parameters; this list was 196 characters long.

the activation of a tag is accomplished by magnetic induction[22] (Chawla and Ha 2007; Want 2006). NFC offers two major functional advantages over RFID. First, an NFC tag can provide substantially more storage space while retaining jewelry-scale dimensions. Among tags that have NFC forum-supported ISO 14443A infrastructure and use the popular (and widely-supported) MIFARE Classic protocol, the smallest is a paper-thin inlay with dimensions of 18x18 millimeters and a user memory of 716 bytes (BuyNFCTags 2013; RapidNFC 2013). NFC tags are also increasingly supported by personal mobile technology. A variety of newer-generation Android and Blackberry smartphones are currently NFC chip-enabled, which means that they are capable of writing to and reading NFC tags (Carter 2011; McFerran 2012). A search of the Google Play store yields more than 200 apps for reading and/or writing NFC tags. Given that smartphones are a relatively accessible and versatile technology, they may be more feasible for services to implement than the specialized read/write devices required for RFID. However, as of the time of publication, emergency medical services in Ontario do not supply ambulances with smartphones, so there is nonetheless a barrier to the use of NFC technology in the near future. With respect to form factors, the small projected area and wafer-like structure of NFC tags makes them ideal for embedding in a variety of designs; my first formal iteration is the red blood cell concept shown in Figure 2.

The third and final digital storage option I investigated is desirable for

22 Magnetic induction is the generation of a potential difference (essentially, the capability to potentiate a current) across a conductor upon the conductor's exposure to a fluctuating magnetic field.

its familiarity and accessibility. QR codes have gained widespread use in advertising and their functionality is well understood (as evidenced by the fact that two participants in the initial round of interviews independently suggested the use of QR codes for information storage). They can be scanned by any smartphone with a camera and a QR reader app, further reducing the technological barrier to implementation among emergency medical services. The major limitation of a QR code is its relatively poor data density at the scale at which I am working. The minimum required physical size of a QR code is dependent on the amount of information stored in it (and thus the complexity of the code), the lighting conditions under which a scan will be conducted, and the deviation of the camera from a head-on view. Working from conservative assumptions about the length of a patient's medical history and the conditions under which the code will be scanned in an emergency, the code's minimum required dimensions are 26x26 millimeters[23] (QRStuff.com 2011a, QRStuff.com 2011b). As depicted in Figure 3, my QR concept has the code embedded in a circular pendant, which is

Figure 2.
NFC red blood cell concept

23 I assumed a scan distance of approximately 76 millimeters, the minimum distance at which my Samsung Galaxy SIII can successfully scan a QR code. (I have assumed a minimal scan distance based on the fact the paramedic will be working in proximity to the patient.) I assumed a distance factor of 7, to account for poor lighting conditions and an off-center scan angle. I imposed a 249 character limit, to accommodate the prototypical 196-character list mentioned earlier, plus some 'padding' to accommodate conditions or medications with longer names.

likely to hang better than a square pendant. As it stands, the minimum diameter for that pendant is 37 millimeters. This would be an extremely large pendant that would be at best uncomfortable and at worst unwearable, particularly since many medical jewelry wearers may be expected to be elderly or infirm. The required code size can be optimized with less conservative assumptions about scanning conditions (effectively constraining the conditions under which users will be able to conduct scans), and a stricter character limit; a viable adjusted code size is 18x18 millimeters[24]. This allows for a circular pendant with a diameter of approximately 26 millimeters, which is large but not uncommon for a commercial pendant.

Figure 3.
QR concept

My attempts to maximize the space available for analog inscription of patient information took two paths. With the first, I sought to maximize the proportion of the jewelry piece on which information could be inscribed. For the hospital band and electrocardiogram (EKG) band concepts shown in Figures 4 and 5 respectively, this meant providing either a large 'plaque' or the entire interior surface of the bracelet for text inscription. My other approach was to provide multiple plaques

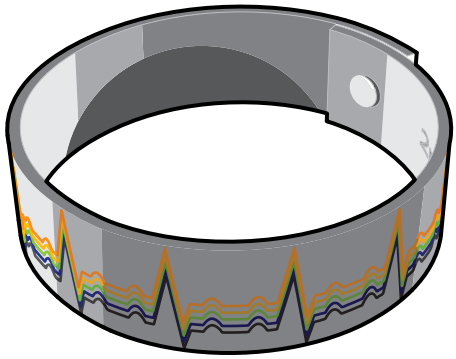
24 Keeping the scan distance constant, I selected a distance factor of 9, which provides for either slightly dim light or a slightly off-center scan. I imposed a 163 character limit, which I expect will accommodate the essential information for many, though not all patient histories.

on which to inscribe information. This is seen in the charm necklace concept shown in Figure 6.

Figure 4.
Hospital band concept

With this design I also created a hierarchy of information, intended to help paramedics rapidly to gauge the available information's relevance to the current emergency, and to judge whether it would be worthwhile to read the inscription. The shape of each charm is an icon of a particular category of medical emergency[25]. Each charm is inscribed with the patient's conditions and medications that are likely to be relevant to that category of emergency.

Figure 5.
EKG band concept



Consider, for example, a patient who has hypertension, major depressive disorder (MDD) and erectile dysfunction (ED) and is taking flunarizine, amitriptyline and sildenafil to treat these disorders, respectively[26]. Hypertension is relevant in a

25 Categories are based on the classification used by Mosby's Paramedic Textbook (Sanders 2007), the standard textbook used in Ontario paramedic curricula.

26 Hypertension refers to chronic elevated blood pressure, where systolic pressure is greater than 140mmHg or diastolic pressure is greater than 90mmHg. Flunarizine is a calcium-channel blocker that can be used to treat hypertension. Amitriptyline is a tricyclic antidepressant that can be used to treat major depressive disorder. Sildenafil is used to treat erectile dysfunction; it is most commonly known

cardiac emergency, as it may contribute to or exacerbate the patient's problem. It may also be relevant in a metabolic emergency, as hypertension is a contraindication for the drug vasopressin, which is used to treat symptomatic diabetes insipidus. MDD is relevant in a psychiatric emergency for the same reason that hypertension is relevant in a cardiac one. MDD is also relevant if the patient is to receive general anaesthetic, as midazolam, a common anaesthetic agent, is contraindicated. ED is not relevant and will not be included on the medical identifier. Flunarizine may have significant interactions with amiodarone, beta-blockers, magnesium, and verapamil and as such it is relevant to cardiac, psychiatric, and metabolic emergencies. Amitriptyline may have significant interactions with epinephrine, salbutamol, atropine, diazepam, dopamine, beta-blockers and lidocaine

and it is therefore relevant to anaphylactic, pulmonary, cardiac, neurological and psychiatric emergencies, as well as to the administration of local anaesthetic.

Figure 6.
Charm necklace concept

as Viagra.

Sildenafil use may result in a potentially fatal interaction with nitroglycerin and it is therefore essential information in cardiac emergencies (Canadian Pharmacists' Association 2011, "Micromedex Drug Interactions" 2013). Therefore, the patient's necklace will have an anaesthetic, an anaphylactic, a cardiac, a metabolic, a neurological, a psychiatric, and a pulmonary charm, inscribed as shown in Table 4. I applied this same hierarchical structure to the QR concept in Figure 3, but in that case I identified the various categories using colour-coding rather than icons.

Table 4.

Categorical organization of hypothetical patient information for use in a medical identifier

Charm	Inscription
Anaesthetic	Major depressive disorder
Anaphylactic	Amitriptyline
Cardiac	Amitriptyline Flunarizine Hypertension Sildenafil
Metabolic	Flunarizine Hypertension
Neurological	Amitriptyline
Psychiatric	Amitriptyline Flunarizine Major depressive disorder
Pulmonary	Amitriptyline

Approaches to Visibility and Recognizability

Based on my interview findings, it is clear that paramedics place a premium on rapidity and efficiency of action; several participants mentioned "load'n'go"

scenarios, in which priority is placed on stabilizing the patient and little time is spent searching for information either at the scene or on the patient's person. Therefore, if a single medical identifier may contain information that is relevant to any stage of pre-hospital care, a paramedic is unlikely to immediately gamble his time on the chance that the device contains information relevant to first stage, stabilizing treatment. Of course, if the paramedic does not check the device and commences a life support algorithm for which the patient is contraindicated, this could be highly problematic. Therefore, I recommend the use of a tiered system, in which each different stage of information is stored on a formally distinct identifier, whose visibility and ease of access is linked to its urgency.

In response to my research findings regarding the form of medical identifiers, I used three approaches to designing for high visibility and/or recognizability. These approaches constitute a first iteration toward my design recommendations for this project, and I used them to generate a set of representative design concepts. I evaluated these design iterations against the specifications that are outlined in Table 3, and created a compliancy table for each design; these can be found in Appendix B. I presented the design concepts to a focus group, the feedback from which I then used to refine my recommendations. Most of my approaches to visibility rely to some extent on the use of visual elements that should already be familiar to paramedics, in order to minimize the conscious effort required of a paramedic in order to notice the design.

The first approach that I considered mimics a form that is likely to be commonly encountered in medical practice or training. This approach is termed surface mimicry, and uses the familiar appearance of an object to communicate its function (Lidwell et al. 2003: 132); this equates to Norman's concept of cultural constraint, in which a specific form becomes associated with a culturally-specific behaviour, and can thus become a signifier of that behaviour (Norman: 86). I developed a form factor based on a hospital bracelet (Fig. 4), which one of my participants had mentioned seeing frequently as a paramedic working in an urban setting.

In a second, similar approach, I used icons to indicate the presence of medical information. While this strategy also makes use of cultural constraints, it differs from the previous approach, as the iconic forms do not have a one-to-one relationship with their referents; instead, they serve as metonymic representations (Hall 2012: 56). I developed a charm necklace concept that uses a combination of anatomical structures, molecular representations and/or conventional symbols of medicine as icons that indicate medical significance (Fig. 6). (The specific icons used, and their combinations, also serve to code specific information, as discussed above.) Two other designs use highly stylized icons that are popularly associated with medicine: a pharmaceutical capsule, and a normal EKG waveform (Fig. 1 and 5). The EKG waveform is already especially linked to emergency medicine through its use on the crests and vehicles of many emergency medical services. A fourth

design references the red blood cell (Fig. 2), also a singular, simple form, but one that is more likely to have significance for the medical community than for the lay community.

My third design approach uses icons as secondary visual cues (Fig. 3). This concept relies on a context-independent use of saturated colour in order to attract attention (Lidwell et al. 2003: 38). The use of bright or neon colour to attract attention was suggested by several participants, while others noted that proposed designs should avoid the use of colours that may blend in with a wearer's clothing. The subtle incorporation of the Star of Life in the QR concept is intended to confirm the design's medical status once the user's attention has been captured. As in the case of the charm necklace design, elements in the QR concept serve a dual purpose: the colours code basic patient information, as is discussed in the previous section.

Revised Design Recommendations in Response to User Feedback

A major general finding to emerge from the focus group process is the ineffectiveness of digital approaches. Participants were unanimously wary of designs that rely on technology. They raised numerous concerns about current access to smartphones, computers and/or wireless internet in the field, about the fiscal and bureaucratic challenges of implementing new technologies for emergency medical services, and about the privacy issues that may arise about the use of a smartphone camera (as required for QR code scanning), or the possible retention of patient data (as could occur with Internet-based solutions or NFC chip readers).

Prior to the focus groups, I had expected that experienced paramedics would be averse to digital information storage, whereas the paramedic trainees would be in favour of it. I based this hypothesis on several factors. The trainees were likely to be younger than the experienced group, and probably more familiar with the day-to-day use of technological devices such as smartphones. Furthermore, the scope of paramedic practice has expanded rapidly over the past two decades, so that paramedics are now able to administer a wider range of medications and procedures. As noted by one experienced participant, this growth is accompanied by a increasing tendency of new paramedics to "stay'n'play" – that is, to stabilize patients and administer treatments on scene. With an increasingly medicalized practice, a new paramedic might be expected to have a greater need for more extensive patient information, which could be provided by a digital storage approach. However, in

contrast to my expectations, the paramedic trainee group was as opposed to the use of digital information storage as were the experienced paramedics. The trainees' concerns were also very similar to those of the experienced group; they cited confidentiality issues, and the time-consuming and unwieldy nature of a system that involves electronic scanning.

One participant provided an important insight into paramedics' distaste for technological approaches. He revealed an adage shared by emergency personnel: "The rule in fire and ambulance is the piece of equipment is going to fail when you need it." It seems clear that a preference for analog approaches is therefore ingrained in the tacit knowledge of paramedics. Barring a massive shift in the information transfer practices used in the prehospital care field, I recommend the use of analog information storage methods in the design of medical identification jewelry (Table 5). Therefore, I recommend rejecting the digital approaches described above, in particular the QR code and NFC red blood cell concepts (Figs. 2-3), whose forms are closely tied to their approaches to information storage (Tables 6-7). The form of RFID pill concept received substantial positive feedback, and was subject to suggestions for alternative modes of information storage. My revision and evaluation of the pill concept will be discussed further at a later point.

Another major finding from the focus groups concerns the number of

Table 5.
Revised specifications required for medical jewelry designs to successfully address paramedics' needs

Recommendation	Requirements
Visibility	Use attention-getting design elements
Recognizable	Use design elements that are distinct from commercial jewelry, and/or distinctly medical; use distinct elements around the chain or band to improve 360-degree recognizability
Accessibility	Require only one step between recognition of device and accessing of patient information. Preferably, use a flip action for information access.
Analog	Use analog (non-technological) approaches to information storage.
Readable	Any text elements follow accessibility guidelines such as those listed in the United States Federal Aviation Administration's Human Factors Criteria for Displays (Ahlstrom and Kudrick 2007).
Relevance of information	Include only information about severe or potentially fatal contraindications and hypersensitivities to emergency-relevant drugs and therapies
Three-tier information architecture	Display information relevant to life support drugs and therapies, non-life support paramedic-administered drugs and therapies, and pre-admission hospital-administered drugs and therapies on visually and geographically distinct devices

Table 6.
Compliancy table for QR code concept

Recommendation	Requirements	Design Compliance	Discussion
Visibility	Use attention-getting design elements	Yes	The form is simple and graphic, and uses bright, saturated colours.
Recognizability	Use design elements that are distinct from commercial jewelry, and/ or distinctly medical; use distinct elements around the chain or band to improve 360-degree recognizability	No	The form and colours are not readily associated with medicine, and may have other connotations (e.g., Pride symbol). Furthermore, the chain does not have any recognizable elements.
Accessibility	Require only one step between recognition of device and accessing of patient information. Preferably, use a flip action for information access.	No	The use of QR technology requires three intermediate steps: accessing a smartphone, opening a QR reader app and scanning.
Analog	Use analog (non-technological) approaches to information storage.	No	The use of a QR code to store patient information is digital.

Recommendation	Requirements	Design Compliance	Discussion
Readable	Any text elements follow accessibility guidelines such as those listed in the United States Federal Aviation Administration's Human Factors Criteria for Displays (Ahlstrom and Kudrick 2007).	Yes	The use of electronic storage allows for the use of larger and more readable text.
Relevance of information	Include only information about severe or potentially fatal contraindications and hypersensitivities to emergency-relevant drugs and therapies	N/A	The information content is not dependent on the form of the design.
Three-tier information architecture	Display information relevant to life support drugs and therapies, non-life support paramedic-administered drugs and therapies, and pre-admission hospital-administered drugs and therapies on visually and geographically distinct devices	N/A	All initial design recommendations address only one tier of the information architecture.

Table 7.
Compliancy table for NFC red blood red cell concept

Recommendation	Requirements	Design Compliance	Discussion
Visibility	Use attention-getting design elements	Yes	The form is simple and graphic, and uses a bright, saturated colour.
Recognizability	Use design elements that are distinct from commercial jewelry, and/ or distinctly medical; use distinct elements around the chain or band to improve 360-degree recognizability	No	The form is very simplistic and may not be readily associated with medicine, and the chain does not have any recognizable elements.
Accessibility	Require only one step between recognition of device and accessing of patient information. Preferably, use a flip action for information access.	No	The use of NFC technology requires two intermediate steps: accessing a smarthphone and scanning.
Analog	Use analog (non-technological) approaches to information storage.	No	The use of NFC technology to access patient information is digital.

Recommendation	Requirements	Design Compliance	Discussion
Readable	Any text elements follow accessibility guidelines such as those listed in the United States Federal Aviation Administration's Human Factors Criteria for Displays (Ahlstrom and Kudrick 2007).	Yes	The use of electronic storage allows for the use of larger and more readable text.
Relevance of information	Include only information about severe or potentially fatal contraindications and hypersensitivities to emergency-relevant drugs and therapies	N/A	The information content is not dependent on the form of the design.
Three-tier information architecture	Display information relevant to life support drugs and therapies, non-life support paramedic-administered drugs and therapies, and pre-admission hospital-administered drugs and therapies on visually and geographically distinct devices	N/A	All initial design recommendations address only one tier of the information architecture.

required steps that paramedics will tolerate in a system in order to retrieve patient information. As reported above, I initially found that paramedics require a system with minimal steps between identification of the medical jewelry and retrieval of information. Over the course of the focus groups it became clear that the complexity of the information retrieval process is a major and non-negotiable concern for paramedics, and that in fact they strongly prefer designs that require only one step for information retrieval. At some point during each focus group session, every participant expressed a specific preference for a design with a "flip" mechanism, that is, where the information on the device can be accessed in one step by flipping the text-bearing part of the device. Several participants mentioned that this is how they access information on most current medical jewelry, and commented that this is one existing design feature that works effectively for them. I therefore recommend the adaptation of any medical jewelry designs so that patient information may be accessed via the flip mechanism (Table 5). On this basis, I also reject the charm necklace concept (Fig. 6), which necessitates multiple steps of flipping through the various charms in order to find the one that is relevant to the particular emergency (if in fact it is present on the necklace) (Table 8).

Hospital band concept. The concept that received the best response during the focus group process is the hospital band design (Fig. 4). This design received substantial attention and commentary from most participants. Three participants chose this as their favourite design, and another as his second-favourite. It is worth

Table 8.
Compliancy table for charm necklace concept

Recommendation	Requirements	Design Compliance	Discussion
Visibility	Use attention-getting design elements	No	The use of multiple charms with relatively complex forms, and the use of plain metal may too closely resemble commercial jewelry.
Recognizability	Use design elements that are distinct from commercial jewelry, and/ or distinctly medical; use distinct elements around the chain or band to improve 360-degree recognizability	No	Several of the charms are not easily recognizable (e.g., Anaesthetic, Infectious, Pulmonary), and the chain does not have any recognizable elements.
Accessibility	Require only one step between recognition of device and accessing of patient information. Preferably, use a flip action for information access.	No	The use of emergency-specific charms to store patient information necessitates flipping through, identifying and judging the relevance of multiple charms.
Analog	Use analog (non-technological) approaches to information storage.	Yes	The use of charms to store patient information is analog.

Recommendation	Requirements	Design Compliance	Discussion
Readable	Any text elements follow accessibility guidelines such as those listed in the United States Federal Aviation Administration's Human Factors Criteria for Displays (Ahlstrom and Kudrick 2007).	No	The use of multiple charms necessitates a small charm size to ensure wearability. This in turn necessitates the use of a small text size.
Relevance of information	Include only information about severe or potentially fatal contraindications and hypersensitivities to emergency-relevant drugs and therapies	N/A	The information content is not dependent on the form of the design.
Three-tier information architecture	Display information relevant to life support drugs and therapies, non-life support paramedic-administered drugs and therapies, and pre-admission hospital-administered drugs and therapies on visually and geographically distinct devices	N/A	All initial design recommendations address only one tier of the information architecture.

noting that these were the four fully-certified paramedics, all of whom have at least several years of field experience. All participants commented that the bracelet is instantly recognizable. Immediately upon seeing the drawing, one participant stated, "This I already recognize…if I saw this, I'd be like 'what is this?'" Another participant stated that it was the only design that she would instinctively recognize as medical in nature. The hospital band-like design also seems likely to encourage paramedics to check for information: several participants stated that if they see something that looks like a hospital band, they will probably examine it. Participants also liked the perforated, foldover-style band, which they felt provides an additional visual cue as to its medical status. This band style was implemented specifically in response to the comments of one first-round participant, who noted that the generic metal chains used on current medical jewelry make that jewelry impossible to recognize if looked at from the wrong angle. The use of a distinctive band, and especially one that is already associated with medical information as in the case of the perforated hospital band, increases the design's 360-degree recognizability. Based on the positive response to this design concept, I recommend developing it to a prototype stage for user-testing.

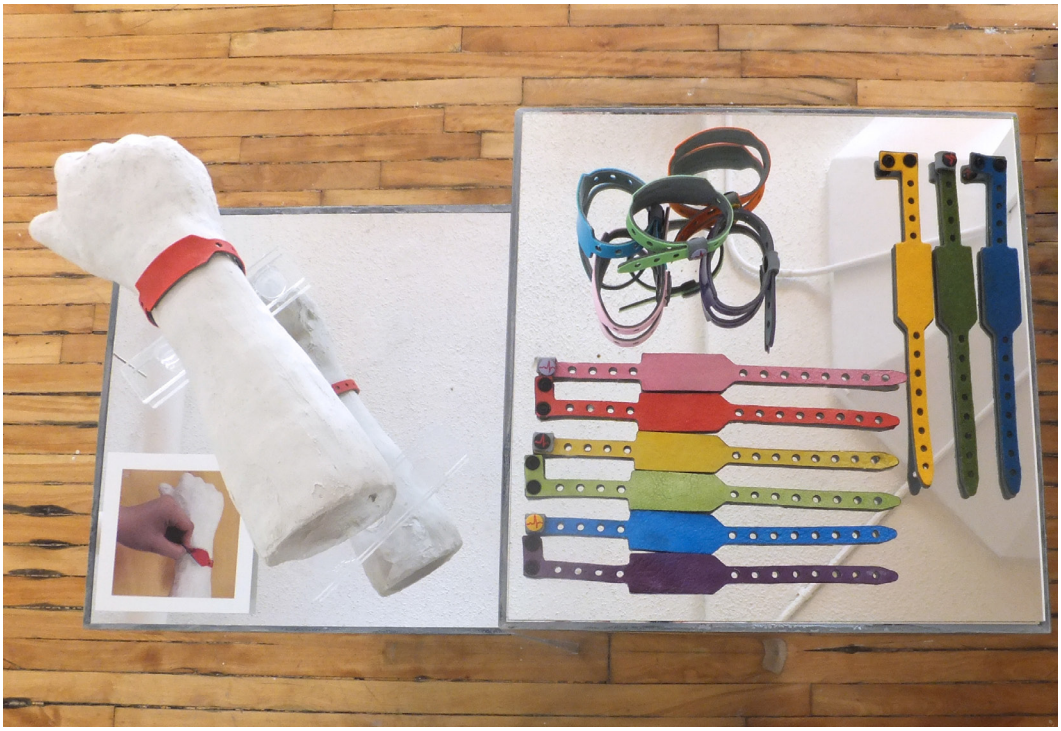
Some concerns were raised about this design, in particular, its wearability and the ease of accessing information engraved on the inner surface of the plaque. As described above, all participants expressed a preference for accessing information via a flip mechanism.

The initial design, featuring a wide metal plaque on a fairly wide but snug-fitting leather band, would be very difficult to flip. I therefore recommend adapting the design so that it could be made entirely out of a flexible material (Figure 7). As suggested by one participant, debossed silicone is a durable option for presenting engraved text (especially in comparison with leather, which can become discoloured, reducing the constrast between background and text, and on which engraved or stamped text can be worn away). Therefore, I recommend the use of debossed, colour-filled silicone for the inner, text-engraved surface of the bracelet. In order to address the concerns about wearability, and provide some options for wearers with different personal styles and budgets[27], I recommend the use of a variety of materials with varying price points and aesthetics for the outer surface of the bracelet.

Figure 7.
The flip mechanism applied in a hospital band concept prototype

27 The need to accommodate different budgets was also mentioned by several first-round and focus group participants, for a variety of reasons. Some referenced the importance of making any system accessible to low-income users, who make up a large majority of the patients seen in urban paramedic practice. Others stated that it is helpful to work with something that is not very precious, in case they need to cut it in order to read it or to access the patient's limb; one participant cited a patient who became angry that paramedics had cut off his expensive jeans in order to treat his badly injured leg.

Figure 8.
Hospital band concept prototypes executed in a variety of materials including silicone, high-quality wool felt and dyed and stained deerskin. The prototypes have custom acrylic snaps that feature the characteristic EKG wave.



These materials may include dyed or stained deerskin, high-grade wool felt, and silicone. In order to provide a further degree of recognizability and customizability, I recommend the use of custom fabric snaps featuring the emblematic EKG wave, rendered in acrylic, sterling silver, and gold-plated sterling silver (Figure 8). To allow for ease of reading, I recommend orienting the engraved text so that it should automatically face the reader when the bracelet is flipped over[28]. Finally, to maximize readability, I recommend executing the inner band in light gray silicone, with black debossed text, as studies have found that dark text on a light background is easier

28 I have assumed that the reader will be facing the wearer. The orientation of the text (and bracelet itself) should be adjusted to accommodate left-handed wearers.

to read (United States Department of Health and Human Services 2006: 11-1). Meanwhile, a gray background is less likely than a white one to become noticeably marred by dirt, which could decrease readability (United States Department of Health and Human Services 2006: 14-1).

The revised hospital band concept's compliance with my revised design recommendations is summarized in Table 9.

Figure 9.
The flip mechanism applied in the EKG band concept prototype

EKG band concept. The EKG-wave band shown in Figure 5 was another popular option among my focus groups. Functionally, it is in many ways similar to the hospital band concept. Participants praised the recognizability of the EKG wave and commented that they would be likely to inspect the bracelet. Some participants felt that this bracelet was more likely to be accepted by potential wearers, as it is less conspicuous than the hospital band style (although it should be noted that in the context of this study, being less conspicuous is not necessarily a strength). Nonetheless, this concept received a sufficiently positive response from most of the focus group participants that I recommend prototyping it and evaluating its

Table 9.
Compliancy table for hospital band concept

Recommendation	Requirements	Design Compliance	Discussion
Visibility	Use attention-getting design elements	Yes	The design is based on a form that attracts paramedics' attention.
Recognizability	Use design elements that are distinct from commercial jewelry, and/ or distinctly medical; use distinct elements around the chain or band to improve 360-degree recognizability	Yes	The form is based on a hospital band, which paramedics recognize as important and information-laden. The perforated band style and foldover closure improve 360-degree recognizability.
Accessibility	Require only one step between recognition of device and accessing of patient information. Preferably, use a flip action for information access.	Yes	The revised hospital band concept allows paramedics to access patient information via a single flip action.
Analog	Use analog (non-technological) approaches to information storage.	Yes	The use of text inscription on a bracelet is analog.

Recommendation	Requirements	Design Compliance	Discussion
Readable	Any text elements follow accessibility guidelines such as those listed in the United States Federal Aviation Administration's Human Factors Criteria for Displays (Ahlstrom and Kudrick 2007).	Yes	The use of a relatively large plaque allows for the use of large text. The use of black text on a matte, light grey background improves readability.
Relevance of information	Include only information about severe or potentially fatal contraindications and hypersensitivities to emergency-relevant drugs and therapies	N/A	The information content is not dependent on the form of the design.
Three-tier information architecture	Display information relevant to life support drugs and therapies, non-life support paramedic-administered drugs and therapies, and pre-admission hospital-administered drugs and therapies on visually and geographically distinct devices	N/A	All initial design recommendations address only one tier of the information architecture.

functionality in a user-testing setting.

I originally intended the EKG band concept to be executed in leather or vinyl, with a snap closure mechanism. Participants raised concerns about the likelihood of the bracelet falling off, and about the durability of text stamped or printed onto leather. As with the hospital band design, participants responded favourably to my proposed modification of using a solid silicone band, which would allow information access via the flip mechanism (Figure 9), and on which text could be durably debossed. Once again, I recommend that the modified EKG band have black text engraved on a light gray background, and oriented so that the text will automatically face the reader once the bracelet is flipped.

As described above, the original EKG band concept featured a colour-coded system, whereby stacked EKG waves in multiple colours could quickly communicate high-level patient information to a viewer. None of the participants felt that a colour-coded system would be useful. Several stated that they would be unlikely to spend time examining the colour-coding and would be more likely just to read what is inscribed on the bracelet. This is supported by many comments made throughout the first-round interviews and focus groups that indicate paramedics are less likely to use a system that requires multiple steps. Some participants also stated that they would have difficulty remembering a colour-coded system with so many categories (as shown in Figure 6, the proposed system has ten categories). Therefore, in order to simplify the appearance of the bracelet, I recommend discarding the colour-

Figure 10.
EKG band concept prototypes executed with a bright, saturated EKG wave on a black rubber background

coding system and using just one EKG wave, with a relatively heavy weight, on a solid background. To mimic the screens on which paramedics are most likely to view EKGs, thus hopefully further improving the bracelet's visibility, I recommend executing the outer surface in black silicone, with the EKG wave rendered in one of several high-contrast, highly-saturated colours (Figure 10).

My evaluation of the revised EKG band concept against my revised design recommendations is summarized in Table 10.

Pill motif concept. Despite their aversion to digital approaches, many participants responded positively to the form of the red and white pill pendant that was originally intended to store an RFID tag (Fig. 1). While they felt the RFID tag would not be effective, most participants felt that the pill design is recognizable.

Table 10.
Compliancy table for EKG band concept

Recommendation	Requirements	Design Compliance	Discussion
Visibility	Use attention-getting design elements	Yes	The design uses a motif that attracts paramedics' attention, and also uses bright, saturated colours.
Recognizability	Use design elements that are distinct from commercial jewelry, and/ or distinctly medical; use distinct elements around the chain or band to improve 360-degree recognizability	Yes	The EKG wave motif is iconic and associated with medical practice. Because the EKG wave wraps around the band, this improves 360-degree recognizability.
Accessibility	Require only one step between recognition of device and accessing of patient information. Preferably, use a flip action for information access.	Yes	The revised EKG band concept allows paramedics to access patient information via a single flip action.
Analog	Use analog (non-technological) approaches to information storage.	Yes	The use of text inscription on a bracelet is analog.

Recommendation	Requirements	Design Compliance	Discussion
Readable	Any text elements follow accessibility guidelines such as those listed in the United States Federal Aviation Administration's Human Factors Criteria for Displays (Ahlstrom and Kudrick 2007).	Yes	The use of the entire band interior for text inscription allows for the use of large text. The use of black text on a matte, light grey background improves readability.
Relevance of information	Include only information about severe or potentially fatal contraindications and hypersensitivities to emergency-relevant drugs and therapies	N/A	The information content is not dependent on the form of the design.
Three-tier information architecture	Display information relevant to life support drugs and therapies, non-life support paramedic-administered drugs and therapies, and pre-admission hospital-administered drugs and therapies on visually and geographically distinct devices	N/A	All initial design recommendations address only one tier of the information architecture.

Several liked it enough to suggest alternative strategies for information storage that might make the pill design more functional. These suggestions included using the pendant to store a slip of paper with the patient's information typed on it, using the pendant as a case for a micro USB key with the patient's information stored on a text file, and using the pendant as the basis for a scroll mechanism (such as is used in the popular novelty 'banner pens'). I explored these suggestions, and raised them with other participants, but ultimately there was no satisfactory solution. Using the pendant to store a rolled up slip of paper would add three steps to the process of retrieving patient information – opening the pill, removing the paper and unfurling it – and as already established, paramedics need a system with a minimum of steps. The USB key strategy suffers the same problem, in addition to the various weaknesses already attributed to digital storage solutions. Finally, the scroll idea, while promising in that it provided an analog, one-step solution to accessing a relatively large quantity of information, proved impossible to resolve formally: the suspension mechanisms required to ensure symmetrical, one-handed access to the scroll introduced formal complexity that reduced the recognizability of the pill icon (Table 11, Figure 11). Therefore, I do not recommend proceeding with prototyping this design.

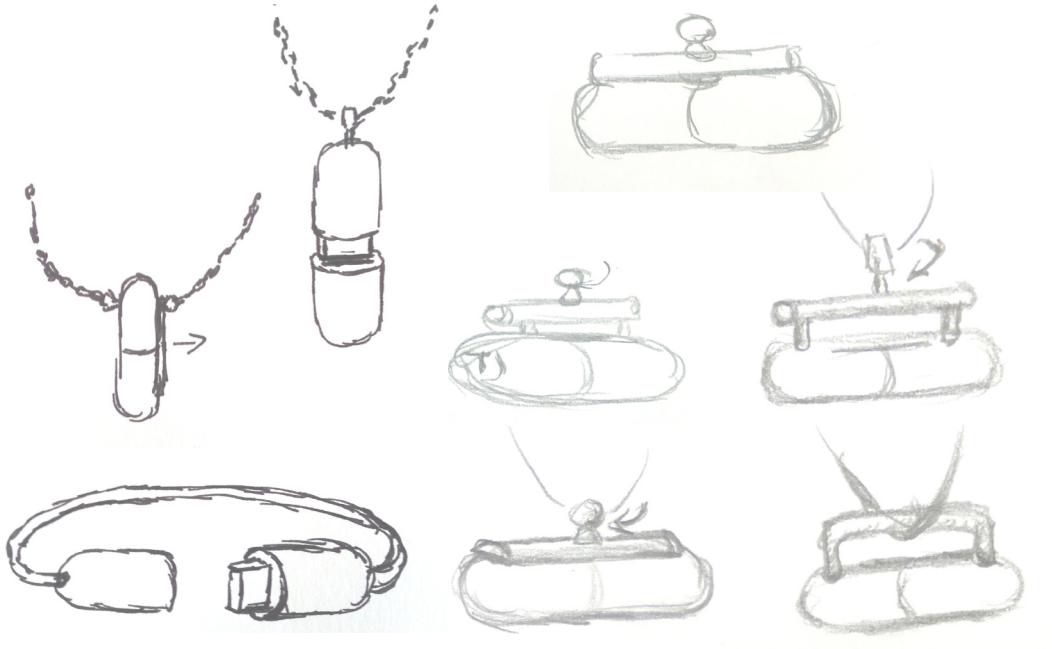
EKG pendant concept. As noted in my initial design recommendations, the information architecture for the proposed system should use three distinct medical identifiers: a necklace, a bracelet and a wallet cards. It is therefore necessary to

Table 11.
Compliancy table for pill concept

Recommendation	Requirements	Design Compliance	Discussion
Visibility	Use attention-getting design elements	Yes	The form is simple and graphic, and uses bright, saturated colours.
Recognizability	Use design elements that are distinct from commercial jewelry, and/ or distinctly medical; use distinct elements around the chain or band to improve 360-degree recognizability	No	The pharmaceutical capsule form is iconic and associated with medical practice, but the chain does not have any recognizable elements. The added complexity of form required for the proposed 'scroll' mechanism reduces recognizability.
Accessibility	Require only one step between recognition of device and accessing of patient information. Preferably, use a flip action for information access.	Yes/No	Several proposed information storage solutions (RFID tag, roll of paper, USB key) require multiple steps to access patient information. The proposed scroll mechanism requires only one step.
Analog	Use analog (non-technological) approaches to information storage.	Yes/No	The use of the pill to contain a roll of paper inscribed with the patient's information is analog. The use of the pill to contain an RFID tag or USB key is digital.

Recommendation	Requirements	Design Compliance	Discussion
Readable	Any text elements follow accessibility guidelines such as those listed in the United States Federal Aviation Administration's Human Factors Criteria for Displays (Ahlstrom and Kudrick 2007).	Yes	The proposed use of electronic storage or analog strategies for information compression (roll of paper, scroll mechanism) allows for the use of larger and more readable text.
Relevance of information	Include only information about severe or potentially fatal contraindications and hypersensitivities to emergency-relevant drugs and therapies	N/A	The information content is not dependent on the form of the design.
Three-tier information architecture	Display information relevant to life support drugs and therapies, non-life support paramedic-administered drugs and therapies, and pre-admission hospital-administered drugs and therapies on visually and geographically distinct devices	N/A	All initial design recommendations address only one tier of the information architecture.

Figure 11.
Attempts to revise the pill concept with a USB key or scroll mechanism



consider how the successful design concepts may be interpreted into these additional forms. During my focus groups, several participants noted that a necklace is the most visible type of identifier on an unstable patient, as paramedics will be working on the patient's bare chest in order to place EKG leads and possibly to defibrillate him. I therefore propose that first stage information be stored on a pendant.

Participants also noted that for patients who are responsive, bracelets are much easier to access as a paramedic is often in contact with a patient's arm, to shake her hand, to measure his blood pressure, or to administer intravenous medications. Therefore, I recommend that second stage information be stored on a bracelet. Finally, wallet cards and paper forms offer a relatively large amount of space on which to store information; however, because they are not located on a

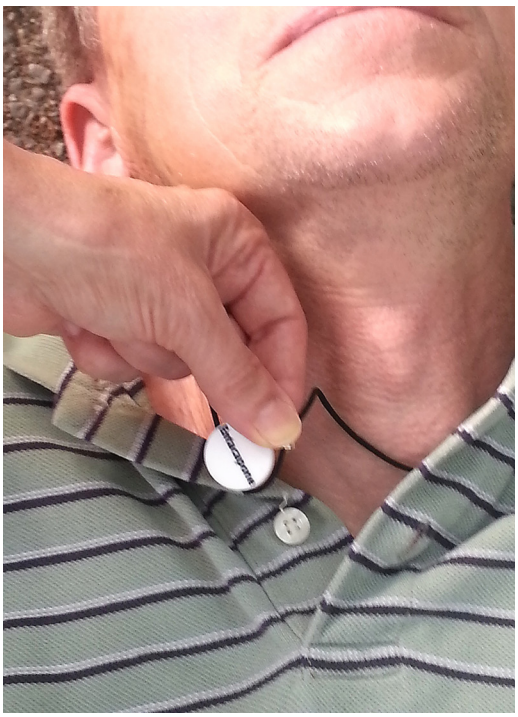
Figure 12.
EKG pendant concept prototypes executed in acrylic and in sterling silver with Ceramit resin

patient's body, they are also relatively inaccessible in a medical emergency. They are therefore an effective option for storing third stage information, which may be quite extensive but which is also low-urgency.

The two successful designs to emerge from the focus groups are bracelets. I recommend that the forms of the requisite necklace and wallet card should reflect the forms of the hospital band and EKG band concepts. I recommend a circular pendant whose obverse has a white EKG wave on a solid, highly saturated, bright red background. In addition to being highly recognizable as established during the focus groups, the EKG motif echoes design elements in both the EKG and hospital

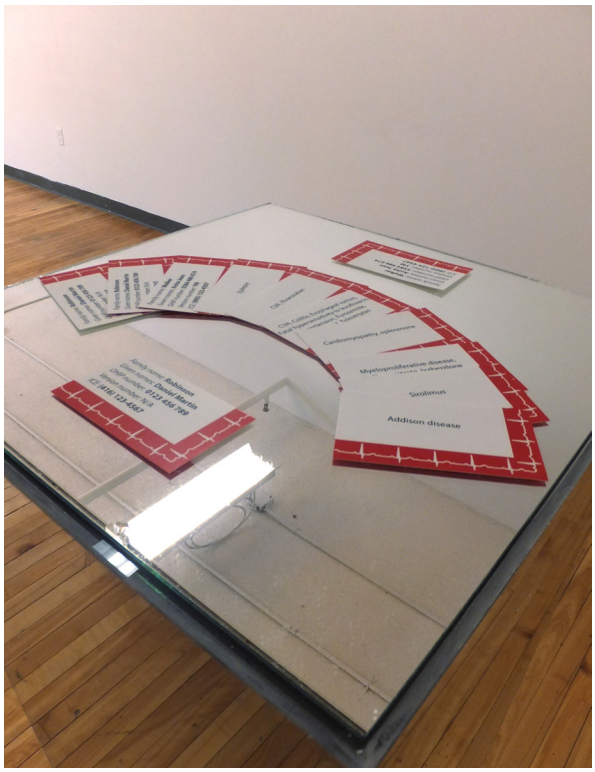
band concepts, providing continuity within the system. As also previously established, the use of a saturated bright red background will attract attention, while the use of high-contrast white for the EKG wave will make it more legible (Figure 12). The reverse of the pendant should have black text on a white or light grey background, once again to aid legibility. To further contribute to legibility, both sides of the pendant should have a matte finish, to prevent harsh light reflections that could interfere with recognition or reading (Dreyfuss 1974: 34). A circular-shaped pendant provides the best combination of wearability, maneuverability and readability. In contrast, a square or horizontally-oriented rectangular pendant would hang poorly if suspended from a central bail and would be difficult to flip if suspended at the sides. Similarly, the text on a vertically-oriented rectangular pendant would be oriented toward one side of the wearer; if the reader were on the incorrect side of the wearer, she would have to manipulate the pendant awkwardly in order to read it. A circular pendant will hang well from a central bail, and allows for text to be oriented horizontally (Figure 13). Ideally, the

Figure 13.
The flip mechanism applied in the EKG necklace concept prototype



pendant should be 20 millimeters in diameter. This is a moderate size for a pendant and should be comfortable for most wearers. At its widest point, a pendant of this size will allow for 12 characters per line at the recommended 14 point font; it will allow for 16 characters per line at a 10 point font, which satisfies the FAA's minimum recommendation of a 16 arc minute visual angle for critical text.

Figure 14.
Wallet card concept prototypes



The compliance of the EKG pendant concept with my design recommendations is summarized in Table 12).

Wallet card concept. For the proposed wallet card, I recommend the use of a United States standard-sized business card (88.9x50.8 millimeters), so that it can be easily stored in a patient's wallet. On both sides of the card, the top and right edges (relative to the body text on the card) should be occupied by a 12.7 millimeter wide red border, with a white EKG wave depicted on it (Figure 14). This should allow for easy recognition of the card whether it is oriented horizontally or vertically in

Table 12.
Compliancy table for EKG pendant concept

Recommendation	Requirements	Design Compliance	Discussion
Visibility	Use attention-getting design elements	Yes	The design uses a simple, graphic motif that attracts paramedics' attention. It also uses bright, saturated colours.
Recognizability	Use design elements that are distinct from commercial jewelry, and/ or distinctly medical; use distinct elements around the chain or band to improve 360-degree recognizability	Yes	The EKG wave motif is iconic and associated with medical practice. Because the EKG pendant is specifically intended to function only in life-saving scenarios where the patient's chest is exposed, the lack of identifiable elements on the necklace chain is acceptable.
Accessibility	Require only one step between recognition of device and accessing of patient information. Preferably, use a flip action for information access.	Yes	The use of a circular pendant suspended from a central bail allows paramedics to access patient information via a single flip action, and to read patient information regardless of on what side of the patient they are standing.

Recommendation	Requirements	Design Compliance	Discussion
Analog	Use analog (non-technological) approaches to information storage.	Yes	The use of text inscription on a pendant is analog.
Readable	Any text elements follow accessibility guidelines such as those listed in the United States Federal Aviation Administration's Human Factors Criteria for Displays (Ahlstrom and Kudrick 2007).	Yes	The restriction of the types of information listed on the pendant means it is likely to contain less information, allowing for larger text size. The use of black text on a matte white background improves readability.
Relevance of information	Include only information about severe or potentially fatal contraindications and hypersensitivities to emergency-relevant drugs and therapies	N/A	The information content is not dependent on the form of the design.
Three-tier information architecture	Display information relevant to life support drugs and therapies, non-life support paramedic-administered drugs and therapies, and pre-admission hospital-administered drugs and therapies on visually and geographically distinct devices	Yes	In combination with the wallet card concept and either the hospital band or EKG band concept, the EKG pendant concept is part of a three-tier information architecture.

a patient's wallet[29]. The red-and-white EKG motif echoes the look of the proposed pendant, as well as the EKG elements in the two proposed bracelet designs. The card's proposed dimensions accommodate approximately 205 characters of 14 point Times text per side; as described above, this should accommodate most relevant medical histories. I recommend that one side of the card be used to indicate third-stage medications and history, while the other side be used for the patient's personal information such as birthdate, address and emergency contact. Several participants mentioned that this type of information can be very helpful in identifying a patient and accessing their full medical history upon arrival at hospital; however, it is unlikely to be very useful a paramedic when she is in the process of stabilizing or treating a patient. Therefore, it is most suitable for inclusion on the wallet card.

My evaluation of the wallet card concept against my revised design recommendations is summarized in Table 13.

29 I have made two assumptions here. First, based on observation, I have assumed that most wallets and card holders are oriented so that the top or right edge of the card (relative to the user) is accessible. I have also assumed that a patient will be likely to store a wallet card with the text oriented toward him, or with a major logo facing outward. I have therefore oriented the borders and text so that this should be possible. Future studies related to this project should seek to verify these assumptions.

Table 13.
Compliancy table for wallet card concept

Recommendation	Requirements	Design Compliance	Discussion
Visibility	Use attention-getting design elements	Yes	The design uses a simple, attention-getting motfic, as well as bright, saturated colours. The EKG motif is oriented so as to be visible in a patient's wallet or card holder.
Recognizability	Use design elements that are distinct from commercial jewelry, and/or distinctly medical; use distinct elements around the chain or band to improve 360-degree recognizability	No	The EKG wave motif is iconic and associated with medical practice.
Accessibility	Require only one step between recognition of device and accessing of patient information. Preferably, use a flip action for information access.	Yes	The card is immediately readable upon recognition.
Analog	Use analog (non-technological) approaches to information storage.	Yes/No	The paper scroll option is analog. The RFID tag and USB key options are digital.

Recommendation	Requirements	Design Compliance	Discussion
Readable	Any text elements follow accessibility guidelines such as those listed in the United States Federal Aviation Administration's Human Factors Criteria for Displays (Ahlstrom and Kudrick 2007).	Yes	The card allows for approximatly 205 characteres of 14 point Times font text per side. The use of black text on a satin white background improves readability.
Relevance of information	Include only information about severe or potentially fatal contraindications and hypersensitivities to emergency-relevant drugs and therapies	N/A	The information content is not dependent on the form of the design.
Three-tier information architecture	Display information relevant to life support drugs and therapies, non-life support paramedic-administered drugs and therapies, and pre-admission hospital-administered drugs and therapies on visually and geographically distinct devices	N/A	All initial design recommendations address only one tier of the information architecture.

Discussion

Project Limitations

This study was constrained by the time limitations of OCAD University's Master's in Interdisciplinary Art, Media and Design (IAMD) program, as well as by the ethical limitations of conducting ethnographic research with Ontario paramedic services. Most significantly, the project was circumscribed by the relatively short timeframe within which I conducted and wrote up my research, and prepared prototypes (sixteen months). As a result, from the outset, I chose to assign the project a narrow focus: the behaviours of paramedics in relation to medical identification jewelry. I identified this as a relevant research problem due to its bearing on the efficacy of medical jewelry, and its absence from the literature. The design recommendations produced from this research should not be considered as a fully resolved solution. They represent a comprehensive analysis of one species within a complex ecology. Future work will necessarily address the unique needs of the other major user group of medical jewelry: wearers.

In addition to the restrictions of my program, I also faced limitations in my work with Ontario paramedic services. When beginning my research, I initially sought to observe paramedics in the field, in order to obtain a more objective insight into their practices. However, the first three services with which I spoke declined this request, citing confidentiality and possible safety concerns. After observing that two of the services seemed hesitant to work with me after my request

for observation, I chose to limit my requests for participation to interviews, after which point I received more positive responses. My exclusive use of interviews is a limitation in light of my activity-centered approach to this study; even though I interviewed participants specifically about their behaviours and analyzed my data from a task-oriented perspective, the data I received were necessarily subject to participants' interpretations of their own actions, the actions of their colleagues, and organizational expectations surrounding their actions. That being said, per Collins' work on the role of language in the acquisition of practical understanding, interviews are an effective strategy for learning about practices, particularly when interview data are analyzed with respect to the collective, that is, when common themes are sought among interview participants.

This study uses a qualitative approach to develop design recommendations in response to the information-gathering behaviour of paramedics. Analysis of the practical efficacy of the recommendations is therefore outside the scope of the study, and must be left for future work. Similarly, throughout this document I made a number of assumptions in order to approximate some of my recommendations. Because this study focuses on qualitatively assessing the tacit knowledge of paramedics, it was not practical to simultaneously undertake the comprehensive human factors study that would have been necessary to fully address these assumptions. This too must be left for the future.

Future Directions for Research

Future work on this project will focus on quantitatively evaluating my recommendations, and on iterating these recommendations through a second phase of user research and testing, this time centered on the wearers of medical jewelry.

As previously mentioned, certain parameters of my recommendations are based on estimations, due to practical limitations in the scope of this study. Moving forward, it will be necessary to conduct further user research, this time with a more physical and quantitative approach, in order to ascertain accurate values for these parameters. In particular, it will be necessary to assess some statistics of patient-paramedic interactions, such as the reading distance for pendants, bracelets and wallet cards (in order to calculate optimal font sizes). It will also be necessary to assess how patients store wallet cards, in order to determine the optimal orientation for identifying graphics on the cards.

Patient-centered iteration must address a challenge faced by many medical design projects: reconciling the apparently oppositional needs of two major user groups, healthcare workers and patients. In the case of medical jewelry, patients are likely to desire devices that do not identify them as such, as described by Pullin (2009). This is reflected in the discreet approach of current medical jewelry, as well as in the comments of some of this study's participants. However, as discussed above, to make medical jewelry discreet is to undermine its very function. It is also expected that patients will have differing personal styles, and thus different preferences as to the appearance of their medical jewelry. However, standardization

of medical jewelry is an important tool for visibility and recognizability among paramedics; this, too, is reflected in the comments of several of this study's participants. Conversely, a design that fails to consider wearers' needs will also be nonfunctional, as it will achieve a low level of compliance from that user group.

In order to effectively address this paradox, future work on this project will need to examine the lived reality of medical jewelry from the perspectives of wearers, and to refine my current recommendations in ways that are amenable to both major user groups. In pursuit of the former goal, wearer research will rely on a user-centered rather than an activity-centered design methodology, as I am more interested in wearers' thoughts, feelings and beliefs about the system than in eliciting a specific action from them (Saffer 2010: 37). I will also use a primarily visceral and reflective approach, rather than the behavioural one I favoured in this study. Whereas behavioural design seeks to understand, respond to, and guide the behaviours of users as they complete a task, Norman argues that visceral and reflective design address the affect and emotion of user experience, respectively. Put simply, visceral design addresses users' innate responses to the physical qualities of a design, while reflective design is concerned with how the physical or conceptual qualities of a product may contribute to users' construction of self (Norman 2004).

I expect that reflective design will be an especially useful approach for overcoming concerns about the stigma of medical jewelry, due to its focus on self-image and social presentation. As described by sociologist Erving Goffman (1986),

stigma is a social phenomenon in which an individual (the stigmatized) diverges from social norms of behaviour or appearance in an undesirable way. Wearers concerned about the conspicuousness of medical jewelry may feel that the jewelry stigmatizes them as weak or incapable; this is borne out by the comments of some of my participants, who stated that they know young men who resist wearing a medical alert because they find the devices emasculating.

Refining my design recommendations to accommodate a range of personal styles will enable me to introduce additional reflective content to the system so that users' emotional experience of it is not rooted solely in stigma. This approach has already been used successfully in the re-conception of eyeglasses by Cutler and Gross, and of prosthetic limbs by Bespoke Innovations (Cutler and Gross 2013, Pullin 2009, Summit 2011). Both of these companies offer a bespoke process to develop devices that closely fit each wearer's physique and personality, while Cutler and Gross also offers an array of ready-to-wear frames that conform to a wide range of styles. By explicitly catering to a wearer's individuality, these companies ensure that her internal narrative of their products is self-determined, rather than stigmatic.

Another opportunity for engaging with reflective design arises from users' more general desire for prestige. Among their six steps for seductive design, designers Julie Khaslavsky and Nathan Shedroff (1999: 49) suggest that one:

- Search for the "aspirational" possibilities in your [product], that is, the opportunities to build meaning and emotional connections to [it and;]
- Correlate these possibilities with the possibilities you find in your audience. These are your priorities for developing the seductive

aspects of your product.

Both Cutler and Gross and Bespoke Innovations exploit aspiration through a heavy emphasis on the materials and fabrication processes of their products. The Cutler and Gross website (2013) cites "its tradition of handcrafting frames…in Cadore, Italy," "the tumbling of the frames in wooden barrels," and the placement of "the brand's gold foil logo on the inside of each right hand temple…[so] the frames keep a quiet elegance about them." Similarly, the Bespoke Innovations website (2013) notes the company's use of vanguard 3D-scanning and -printing technology and "leather, ballistic nylon fabric, [and] chrome plating". Therefore, I expect that incorporating high-quality materials and exclusive fabrication technologies into the brand identity of the proposed system will provide wearers with a positive emotional experience of the system.

Finally, as noted above, it will likely be necessary to solve design conflicts resulting from oppositional needs of paramedics and wearers. Designers Lekshmy Parameswaran and Jeroen Rajimakers (2010) suggest that healthcare design problems benefit from the use of a collaborative design team, with members from each stakeholder group. In the case of this project, future focus groups should be conducted with both paramedics and wearers together. This approach could allow for the application of conflict resolution strategies in refining the design recommendations. Cooperative dialogue amongst wearers and paramedics should yield information about the kinds and magnitudes of design concessions each user

group can tolerate, and might also yield design solutions, either through 'logrolling', in which both user groups make low-impact concessions until they are satisfied, or through integrative agreements, in which novel solutions are generated from the collaborative input of the different users (Klein and Lu 1990).

Works Cited

Ahlstrom, Vicki and Bonnie Kudrick. "Human Factors Criteria for Displays: A Human Factors Design Standard Update of Chapter 5." Atlantic City, NJ: Federal Aviation Administration, William J. Hughes Technical Center, 2007.

Barcode Technology Solutions. "Encoding RFID Tags with the Label Design Module." Barcode Technology Solutions, n. d. Retrieved 20 May 2013 from http://bartechsol.com/images/RFID%20Tag%20Tutorial.pdf.

Bespoke Innovations. "What is a Fairing?" Bespoke Innovations, 2013. Retrieved 20 May 2013 from http://www.bespokeinnovations.com/content/what-fairing.

BuyNFCTags. "SMARTRAC MiniBlock Standard 1K Clear Wet NFC Inlay." Wireless Sensor Technologies, 2013. Retrieved 20 May 2013 from http://www.buynfctags.com/smartrac-miniblock-1k-clear-wet-nfc-inlay.html.

Canadian Pharmacists' Association. *Compendium of Pharmaceuticals and Specialties*. Ottawa: Canadian Pharmacists' Association, 2011.

Carter, Jamie. "What is NFC and Why is it in Your Phone?" *TechRadar*, Future Publishing Ltd., 2011. Retrieved 20 May 2013 from http://www.techradar.com/news/phone-and-communications/what-is-nfc-and-why-is-it-in-your-phone-948410.

Chawla, Vipul and Dong Sam Ha. "An Overview of Passive RFID." *IEEE Applications and Practice*. 45.9 (2007): 11-17.

Chi, Tom. "Activity Centered Design." *OK/Cancel*, Tom Chi and Kevin Cheng, 2005. Retrieved 24 Jun 2013 from http://okcancel.com/archives/article/2005/08/activity-centered-design.html.

"Clinician's Pocket Drug Reference." Computer software. Mobile Systems. V.4.2.048, 2013. Retrieved 20 May 2013 from https://play.google.com/store/apps/details?id=com.mobisystems.msdict.embedded.wireless.mcgrawhill.cpdr2011.

Collins, Harry M. *Tacit and Explicit Knowledge*. Chicago: University of Chicago Press, 2010.

Collins, Harry M. "Language and practice." *Social Studies of Science*. 41.2 (2011):

271-300.

Collins, Harry M. and Martin Kusch. *The Shape of Actions: What Humans and Machines Can Do*. Cambridge, MA: MIT Press, 1998.

Cutler and Gross. "Years of Vision and Style 1969-2013." Cutler and Gross, 2013. Retrieved 20 May 2013 from http://www.cutlerandgross.com/about/.

Dreyfuss, Henry. *Designing for People*. Rev. ed. New York: Viking Press, 1974.

"Epocrates." Computer software. Epocrates, Inc. v.1.1325, 2013. Retrieved 05 May 2013 from https://play.google.com/store/apps/details?id=com.epocrates&hl=en.

Geddes, J. S. "Twenty years of prehospital coronary care." *British Heart Journal*. 56.6 (1986): 491-495.

Goffman, Erving. *Stigma: Notes on the Management of Spoiled Identity*. Reissue ed. Toronto: Simon & Schuster, 1986.

Groopman, Jerome. *How Doctors Think*. Boston: Houghton Mifflin, 2009.

Hope Paige Medical ID Marketplace. "Women Styles." Hope Page Designs, Inc., 2013. Retrieved 20 May 2013 from https://www.hopepaige.com/product-category.aspx?ProductCategoryID=117&category=Women+Styles.

IDAutomation. "RFID FAQ & Tutorial." IDAutomation.com, 2013. Retrieved 20 May 2013 from http://www.idautomation.com/barcode-faq/rfid/.

Khaslavsky, Julie and Nathan Shedroff. "Understanding the Seductive Experience." *Communications of the ACM*. 42.5 (1999): 45-49.

Klein, Gary. *Sources of Power: How People Make Decisions*. Cambridge, MA: MIT Press, 1999.

Klein, Mark and Stephen C-Y. Lu. "Conflict Resolution in Cooperative Design." *International Journal for Artificial Intelligence in Engineering*. 4.4 (1990): 168-180.

Kuutti, Kari. "Activity Theory as a Potential Framework for Human-Computer Interaction Research." *Context and Consciousness: Activity Theory and Human-Computer Interaction*. Ed. Bonnie A. Nardi. Cambridge, MA: MIT Press, 1996. 9-22.

Leeming, William. Personal communication. 3 March 2012.

Luker, Kristen. *Salsa-Dancing into the Social Sciences: Research in an Age of Info-Glut*. Cambridge, MA: Harvard University Press, 2008.

McCracken, Grant. *The Long Interview*. Newbury Park, CA: Sage Publications, 1988.

McFerran, Damien. "How to Use NFC Tags With Your Android Mobile Phone." *CNET UK*, CBS Interactive Ltd., 2012. Retrieved 20 May 2013 from http://reviews.cnet.co.uk/mobile-phones/how-to-use-nfc-tags-with-your-android-mobile-phone-50007754/.

MedicAlert Canada. "About MedicAlert." Canadian MedicAlert Foundation, 2013. Retrieved 20 May 2013 from http://www.medicalert.ca/en/about/.

MedicAlert Canada. "How MedicAlert Works." Canadian MedicAlert Foundation, 2013. Retrieved 20 May 2013 from http://www.medicalert.ca/en/join/how/work.asp.

MedicAlert Foundation. "24/7 Emergency Response." MedicAlert Foundation, 2013. Retrieved 20 May 2013 from http://www.medicalert.org/services/everybody/247-emergency-response.

MedicAlert Foundation. "History." MedicAlert Foundation, 2013. Retrieved 18 May 2013 from http://www.medicalert.org/about/who-we-are/history.

MedicAlert UK. "Our History." MedicAlert UK, 2013. Retrieved 20 May 2013 from http://www.medicalert.org.uk/about-us/our-history.

MedicAlert UK. "Why MedicAlert." MedicAlert UK, 2013. Retrieved 20 May 2013 from http://www.medicalert.org.uk/new-to-medic-alert/why-medicalert.

"Micromedex Drug Interactions." Computer software. Truven Health Analytics. v.1.48.0, 2013. Retrieved 05 May 2013 from https://play.google.com/store/apps/details?id=com.thomson.druginteractions&hl=en.

Mol, Annemarie. *The Body Multiple: Ontology in Medical Practice*. Durham, NC: Duke University Press, 2002.

Nardi, Bonnie A. "Activity Theory and Human-Computer Interaction." *Context*

and Consciousness: Activity Theory and Human-Computer Interaction. Ed. Bonnie A. Nardi. Cambridge, MA: MIT Press, 1996. 4-8.

Newton, Bruce. "Toronto EMS – History." Toronto EMS, 2013. Retrieved 20 May 2013 from http://www.torontoems.ca/main-site/about/history.html.

Norman, Donald A. *The Design of Everyday Things*. 2nd ed. New York: Basic Books, 2002.

Norman, Donald A. *Emotional Design: Why We Love (or Hate) Everyday Things)*. New York: Basic Books, 2004.

Norman, Donald A. "Human-centered design considered harmful." *Interactions - Ambient intelligence: exploring our living environment*. 12.4 (2005): 14-19.

Parameswaran, Lekshmy and Jeroen Rajimakers. "People-focused innovation in healthcare." Phillips Design, 2010. Retrieved 20 May 2013 from http://www.design.philips.com/philips/shared/assets/design_assets/pdf/nvbD/july2010/people_focused_innovation_in_healthcare.pdf.

Polanyi, Michael. *The Tacit Dimension*. London: Routledge & Kegan Paul, 1966.

Pullin, Graham. *Design Meets Disability*. Cambridge, MA: MIT Press, 2009.

QRStuff.com. "QR Code Minimum Size." QRStuff, 2011. Retrieved 20 May 2013 from http://www.qrstuff.com/blog/2011/11/23/qr-code-minimum-size.

QRStuff.com. "What Size Should a Printed QR Code Be?" QRStuff, 2011. Retrieved 20 May 2013 from http://www.qrstuff.com/blog/2011/01/18/what-size-should-a-qr-code-be.

RapidNFC. "Which NFC Chip?" RapidNFC Ltd., 2013. Retrieved 20 May 2013 from http://rapidnfc.com/which_nfc_chip.

RFID Canada. "LF Glass Tags." RFID Canada, 2013. Retrieved 20 May 2013 from http://www.rfidcanada.com/products/passive-lf/tags/lf-glass-transponders/.

Saffer, Dan. *Designing for Interaction: Creating Innovative Applications and Devices*. Berkeley, CA: New Riders, 2010.

Sanders, Mick J. *Mosby's Paramedic Textbook*. Rev. 3rd ed. St. Louis: Elsevier, 2007.

Stevenson, A. Larry. “Thanks from Canadian Medic-Alert Foundation.” Canadian Medical Assocation Journal. 91.18 (1964): 980.

Summit, Scott. “Beautiful Artificial Limbs.” TEDxCambridge. Harvard University, Cambridge, MA. 19 November 2011. Retrieved 20 May 2013 from http://www.ted.com/talks/scott_summit_beautiful_artificial_limbs.html.

Tangherlini, Timothy. *Talking Trauma: A candid look at paramedics through their tradition of tale-telling*. Jackson, MS: University Press of Mississippi, 1998.

United States Department of Health and Human Services. *Research-Based Web Design and Usability Guidelines*. Washington, DC: United States Government Printing Office, 2006. Retrieved 20 May 2013 from http://www.usability.gov/guidelines/guidelines_book.pdf.

Universal Medical ID. “Bracelets.” Universal Medical ID Canada, 2013. Retrieved 20 May 2013 from http://www.universalmedicalid.com/mkt_can/category_viewall.php?mastercategory=bracelets.

Universal Medical ID. “Frequent Questions.” Universal Medical ID Canada, 2013. Retrieved 20 May 2013 from http://canada.universalmedicalid.com/canada/frequent.php.

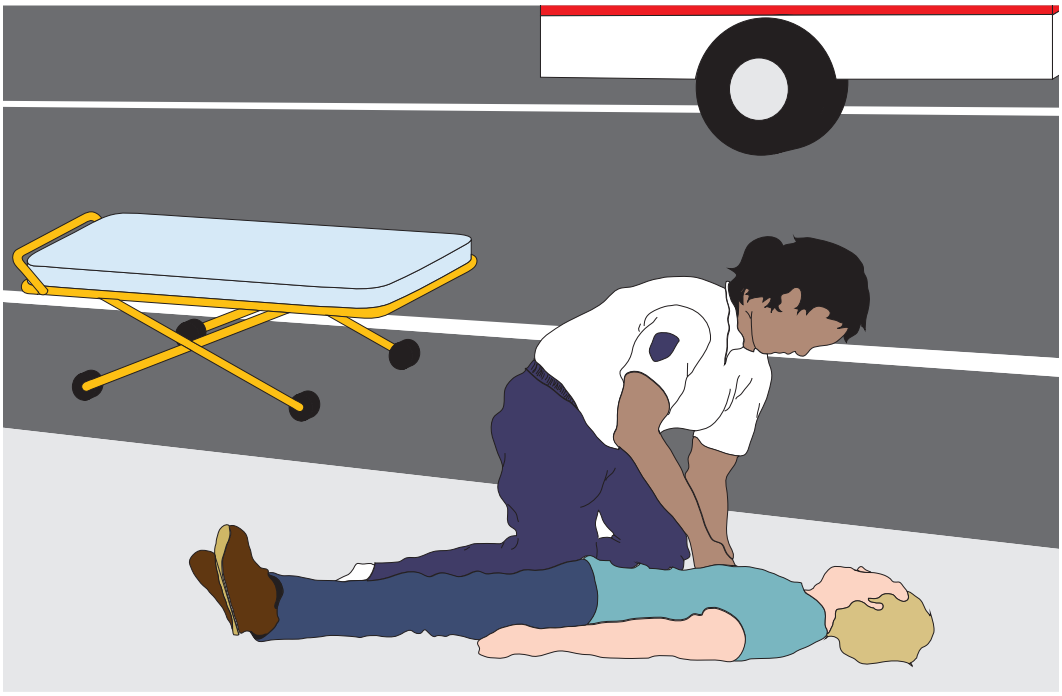
Want, Roy. “An Introduction to RFID Technology.” Pervasive Computing, IEEE. 5.1 (2006): 25-33.

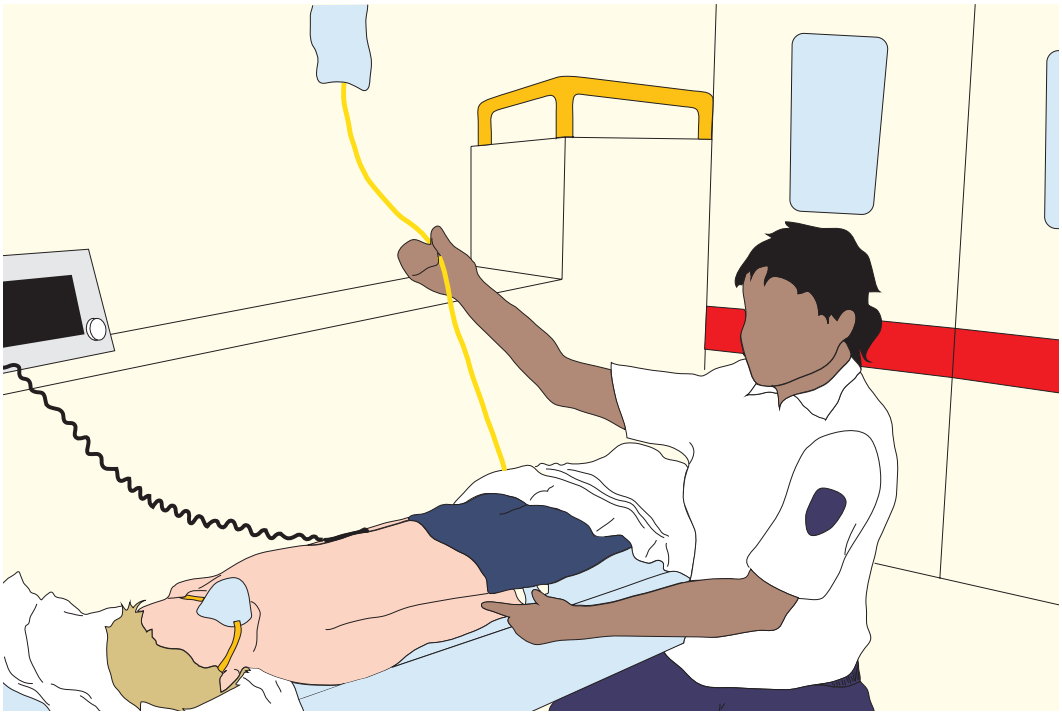
Wittgenstein, Ludwig. *Philosophical Investigations*. Trans. G. E. M. Anscombe. 3rd ed. Malden, MA: Blackwell, 2001.

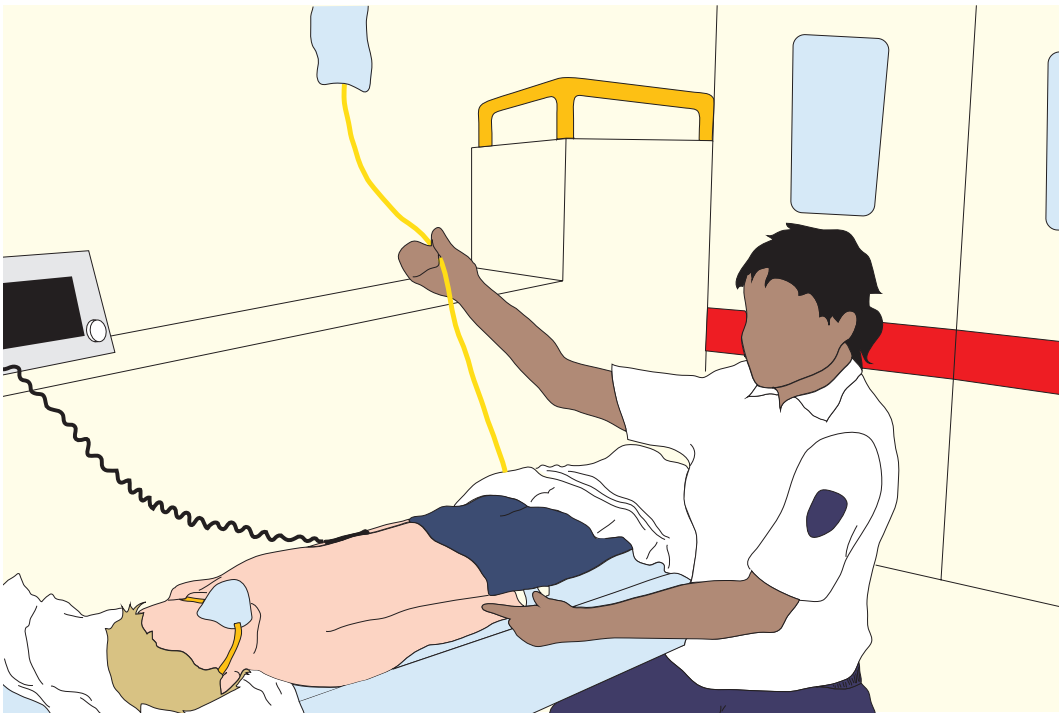
Wyatt, Andrea. “Paramedic Practice – Knowledge Invested in Action.” Journal of Emergency Primary Health Care. 1.3 (2003): Article 9.

Young, Allan. “When Rational Men Fall Sick: An Inquiry Into Some Assumptions Made by Medical Anthropologists.” Culture, Medicine, and Psychiatry. 5 (1981): 317-335.

Appendix A.
Edge case storyboard for paramedic response to a medical emergency involving an unresponsive and unstable patient







Appendix B.
Sketches and documentation of process

Page 90.
Design sketches using motifs commonly seen in paramedic practice, including the Star of Life, the characteristic EKG wave, a hospital band, a prescription bottle, and an EKG electrode

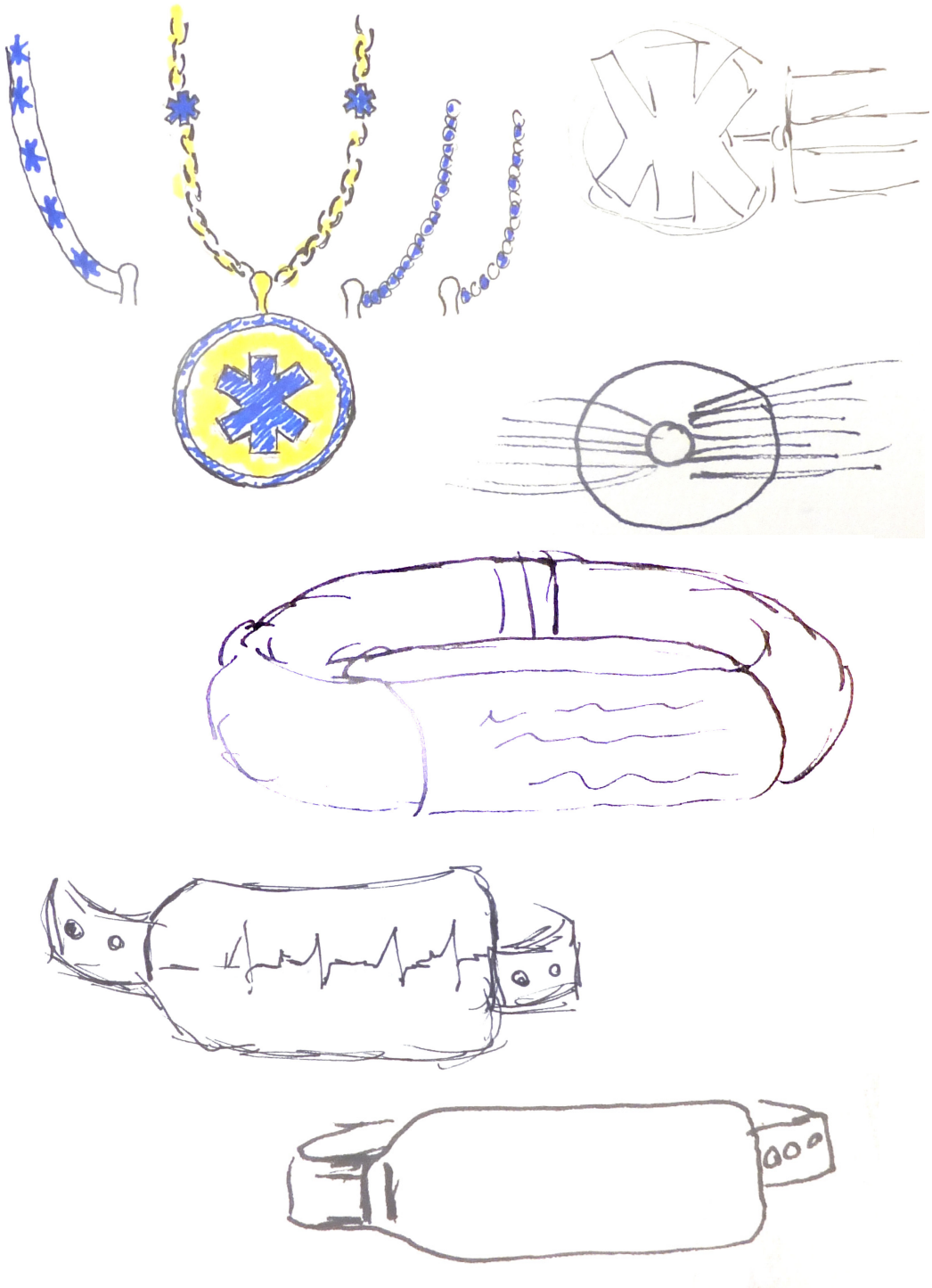
Page 91.
Design sketches featuring pills

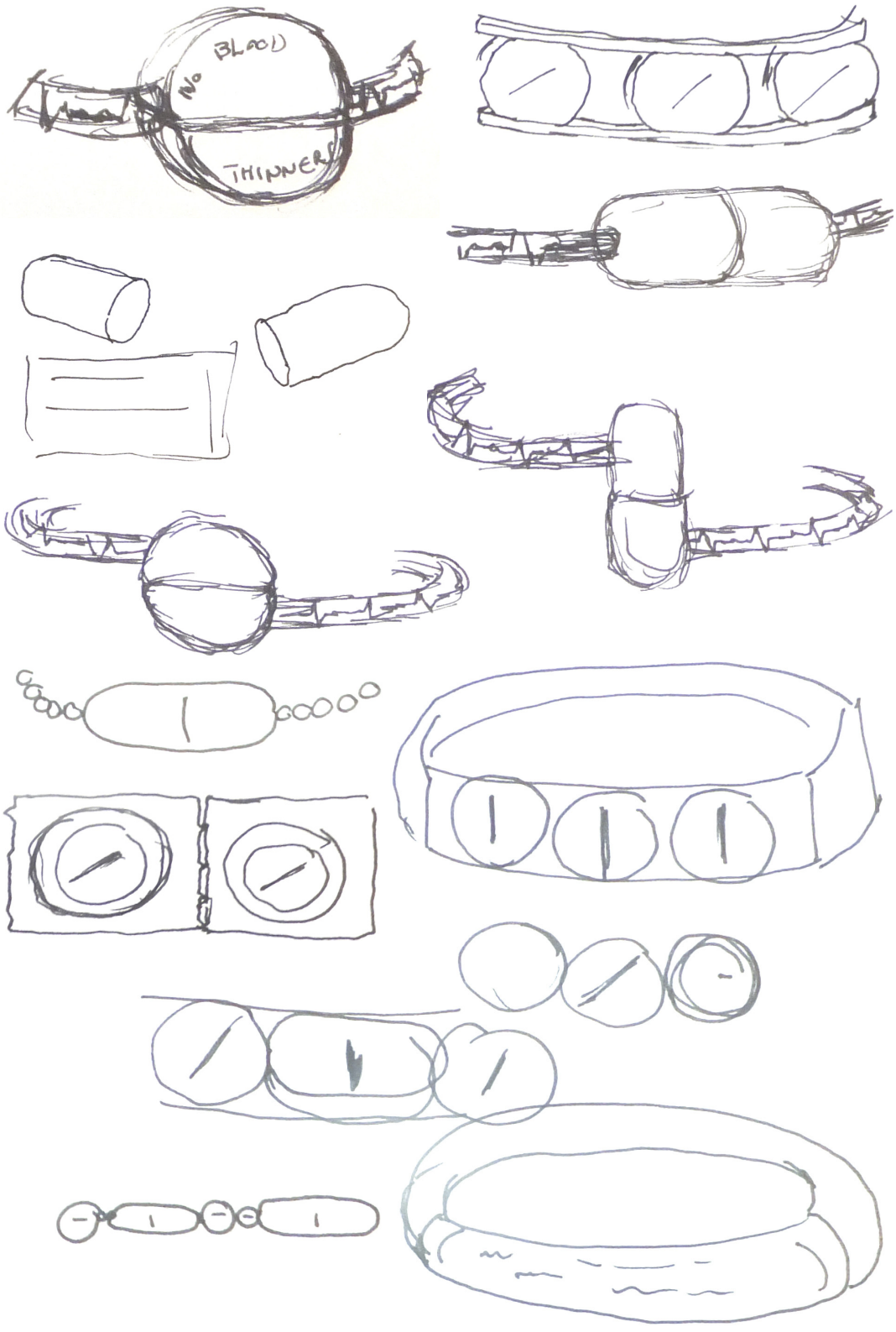
Page 92.
Design sketches featuring the characteristic EKG wave

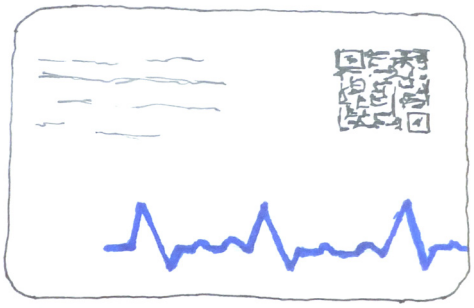
Page 93.
Design sketches featuring QR codes

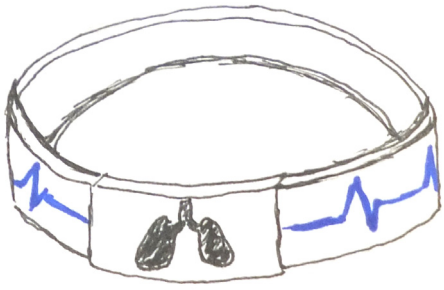
Page 94.
Design sketches and notes featuring concepts meant to use colour-coding

Page 95.
Design sketches featuring interpretations of anatomical structures and biomedical data (including microarrays)

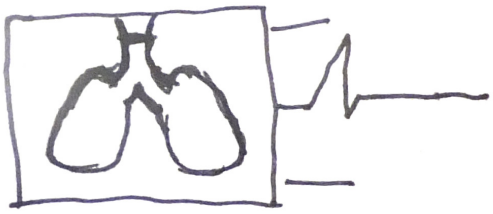



BLOOD
THINNER

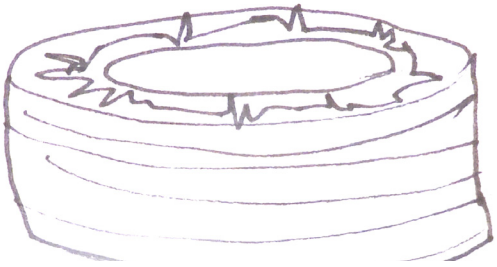


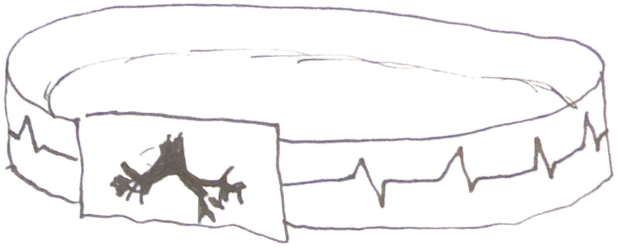


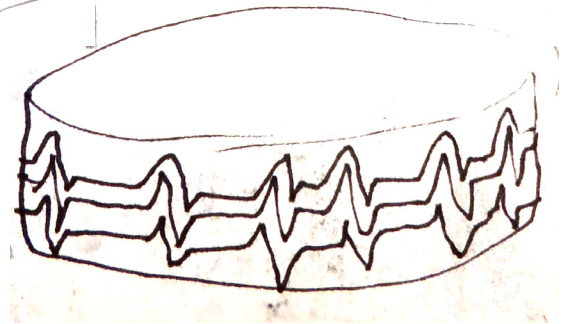
Kawasthan Lake Shield
↳ PQRST wave depicted in lt. blue and dk blue.

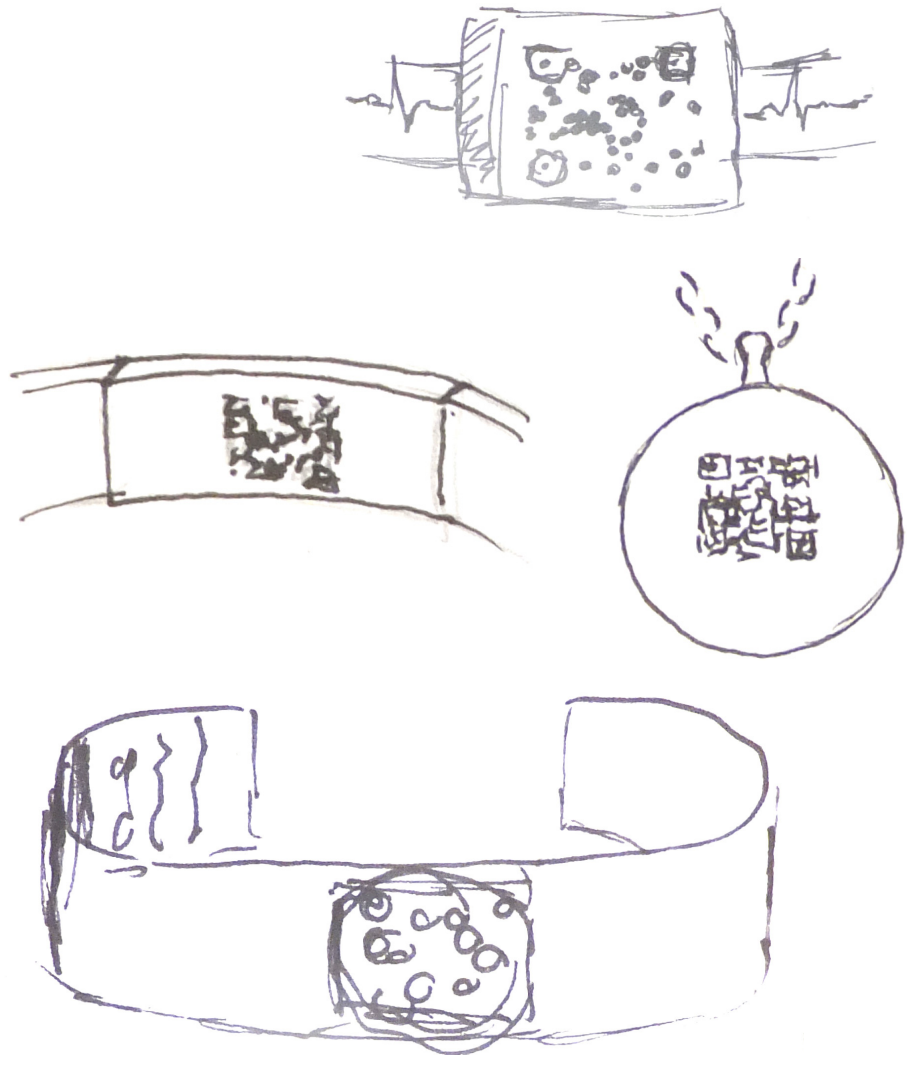


correspa-
top!!
bottles.
backup as
machine
readable



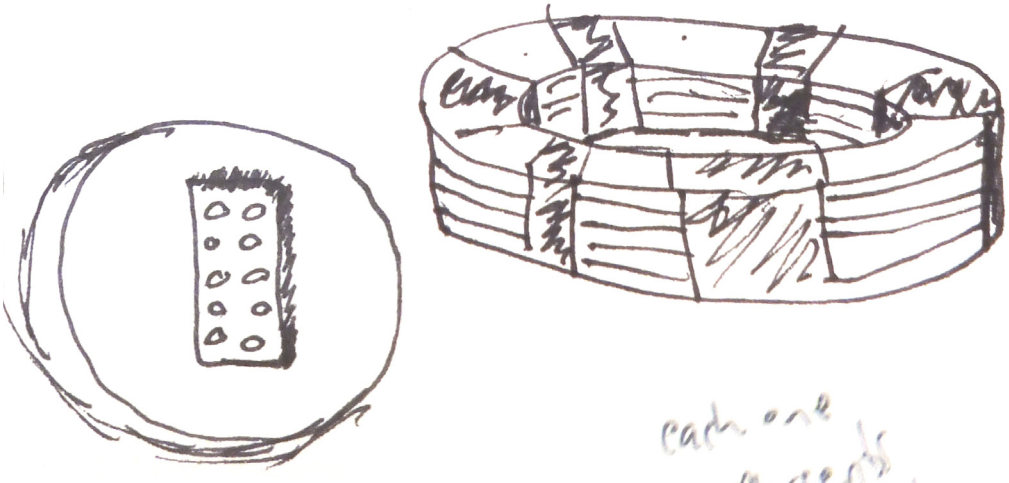




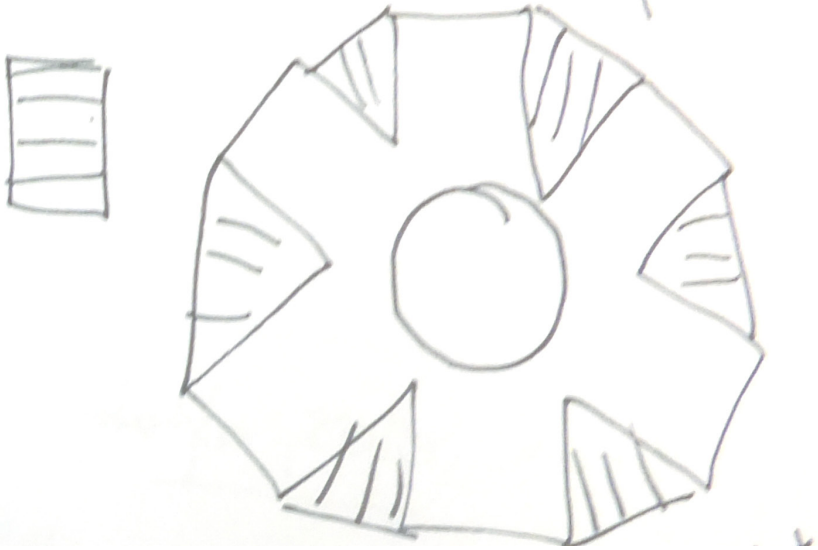


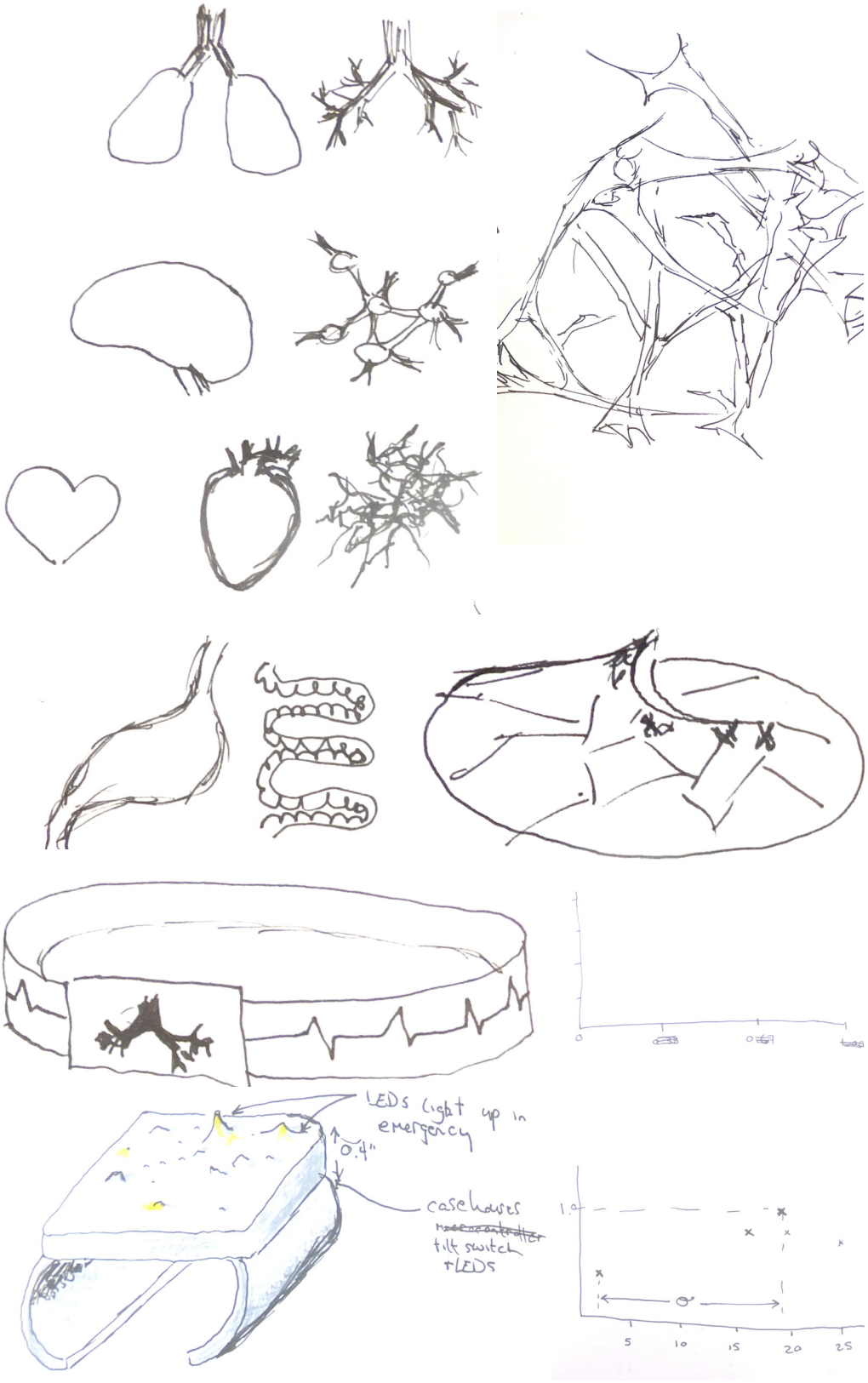
Waterloo EMS

→ suggested colour-coding pill bottles by condition type - gave example of ('red' for hyperbension ... so drugs thought of by cond'n they treat → which then, in terms of diag. / treatment, often broken down by body system)



each one represents a capsule




LEDs light up in emergency
0.4"
case houses
tilt switch
LEDs
1.0
5
10
15
20
25

Page 97.
Painting the EKG band prototypes

Pages 98-99.
Preparing the hospital band prototypes

Page 98 (top to bottom).
Dyeing leather
Laser-cut materials

Page 99 (top to bottom).
Sanding silicone to prepare for gluing inner and outer layers
Applying glue

Page 100-104.
Preparing the EKG pendant prototypes

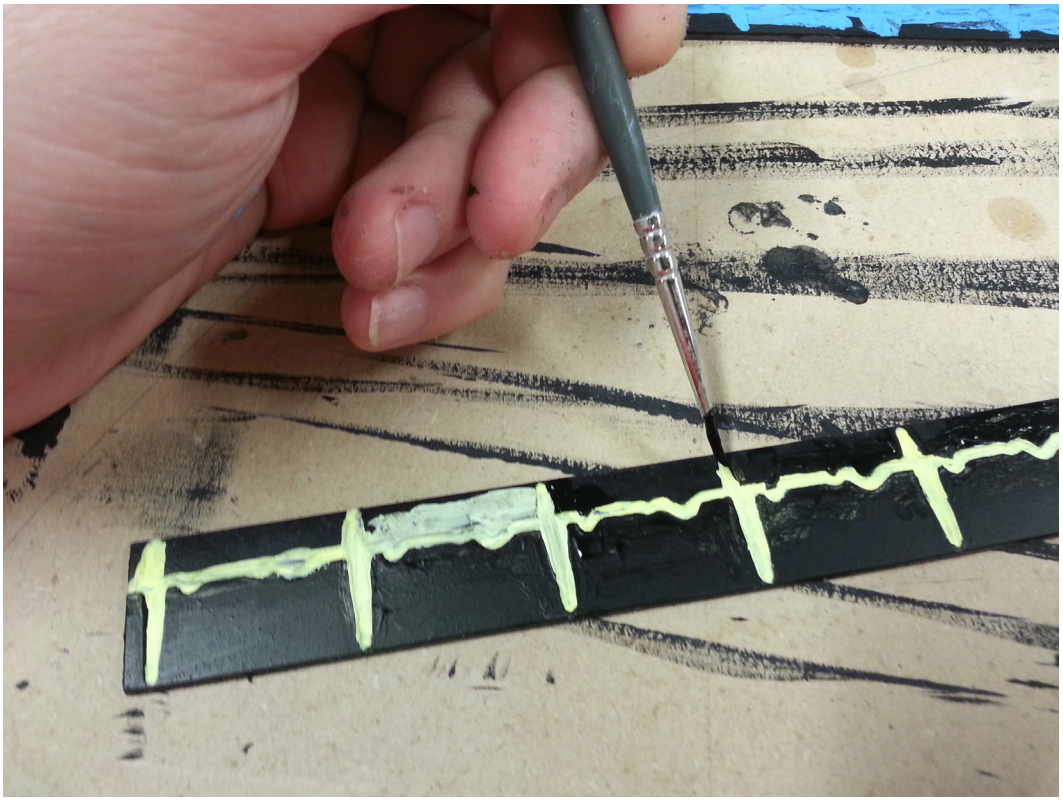
Page 100 (top to bottom).
Assembling the laser-cut materials
Painting over the engraved text

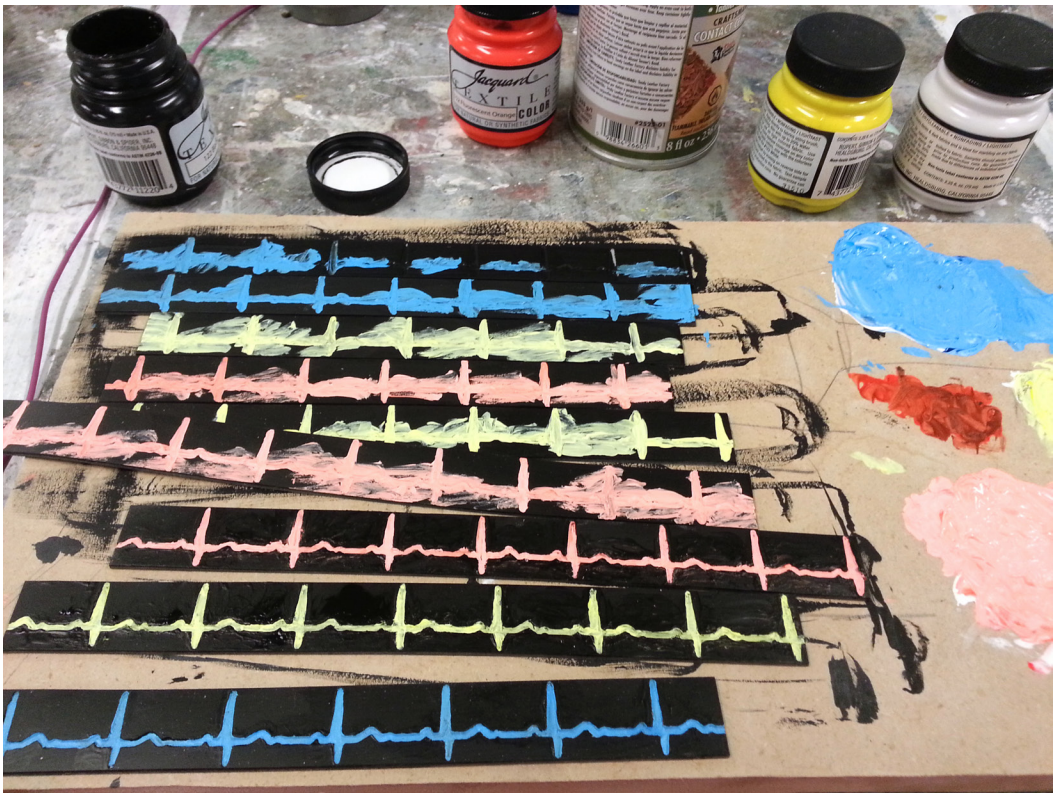
Page 101 (counter-clockwise from top).
Emerying a pendant to reveal the painted, engraved text
Closing a bail
Finished acrylic pendant

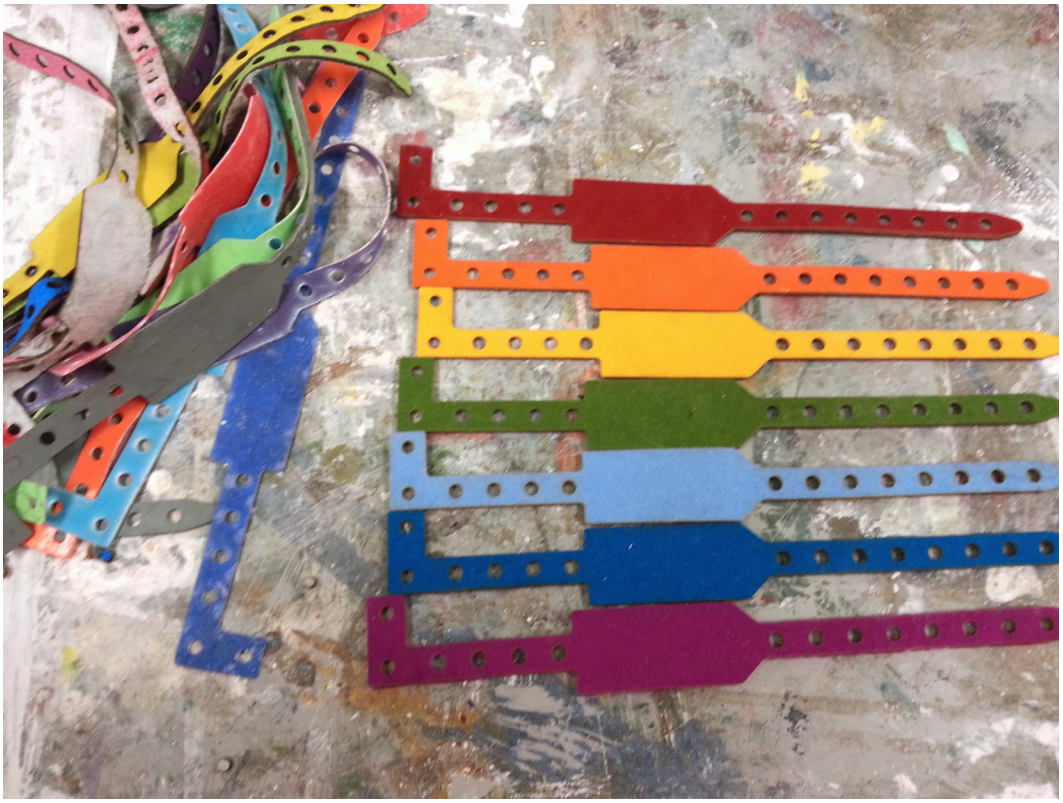
Page 102 (top to bottom).
Filing the sprue off of a cast silver pendant
Two pendants sitting in patination solution

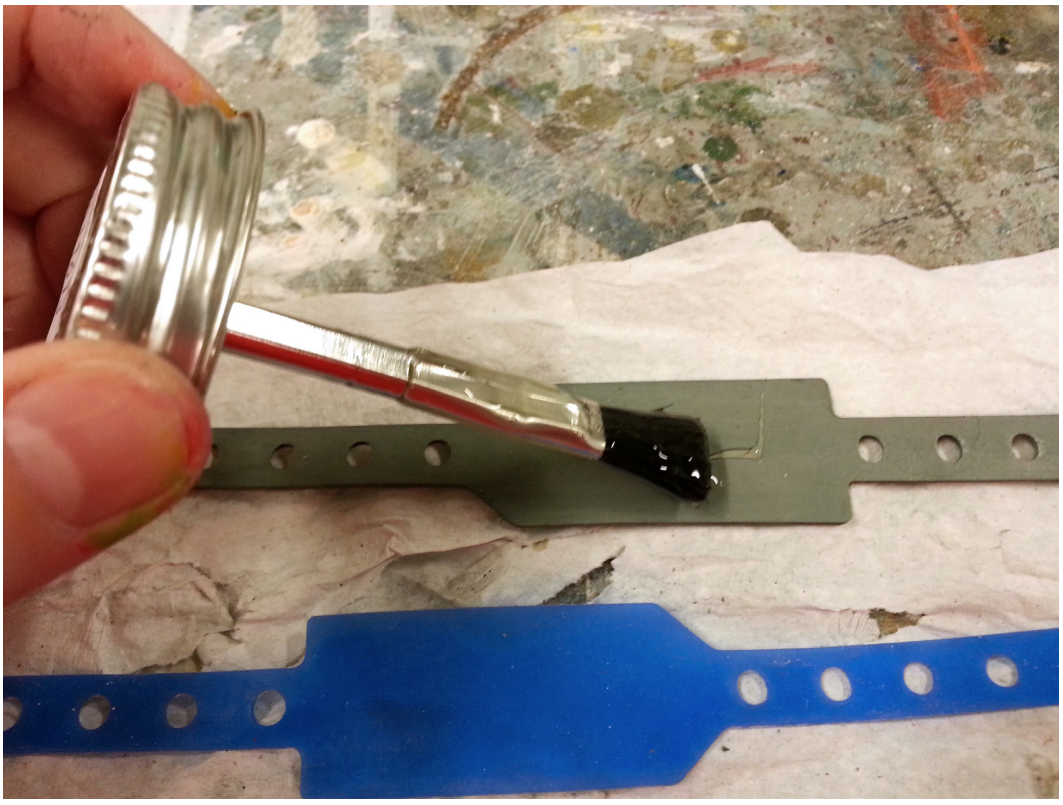
Page 103 (top to bottom).
Pendants covered in patina
Pendants with the patina emeried off of the high spots

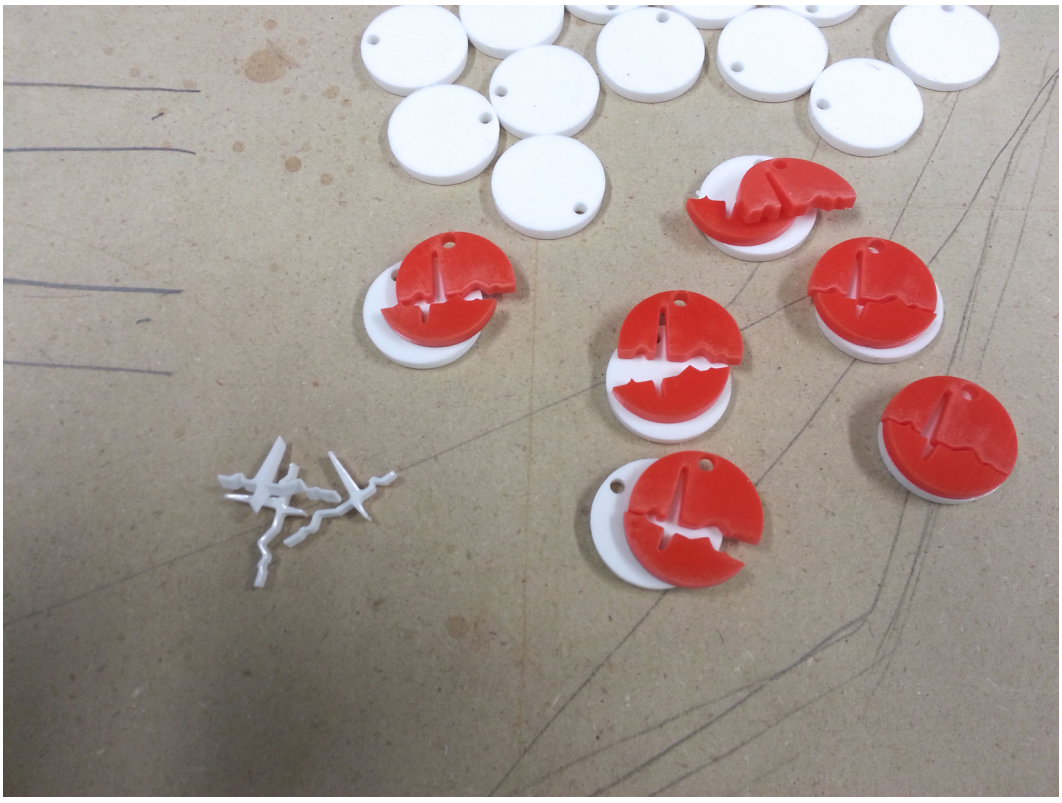
Page 104.
Silver pendants with Ceramit resin curing

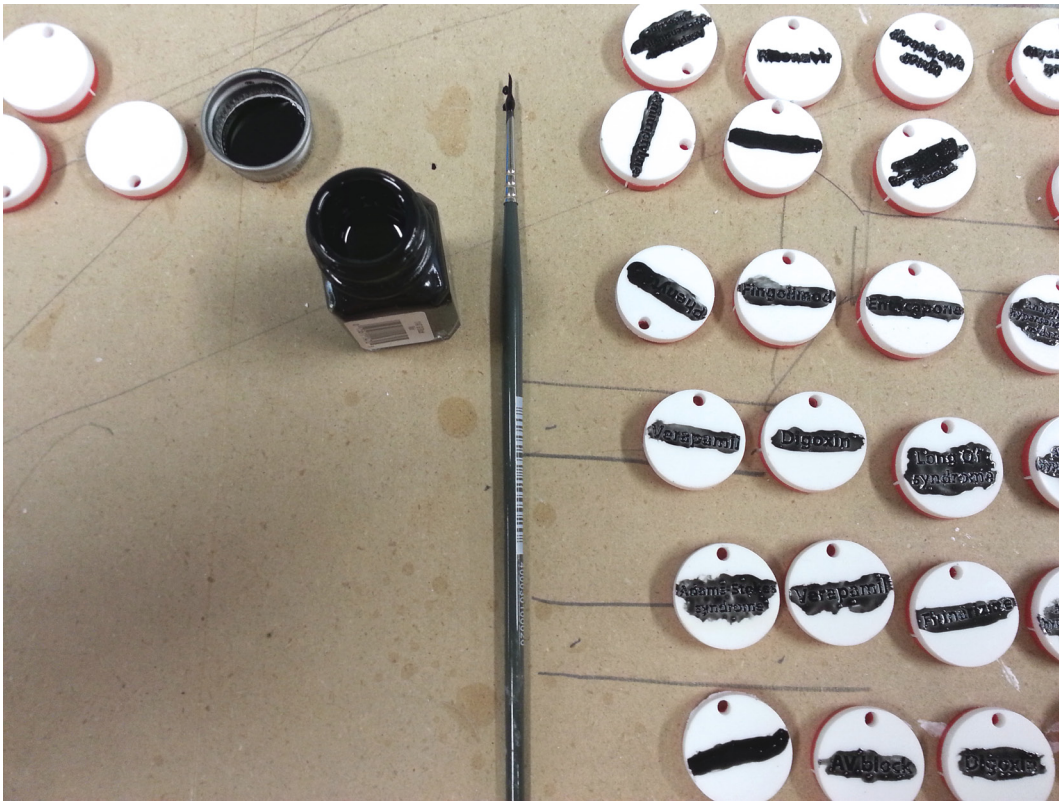


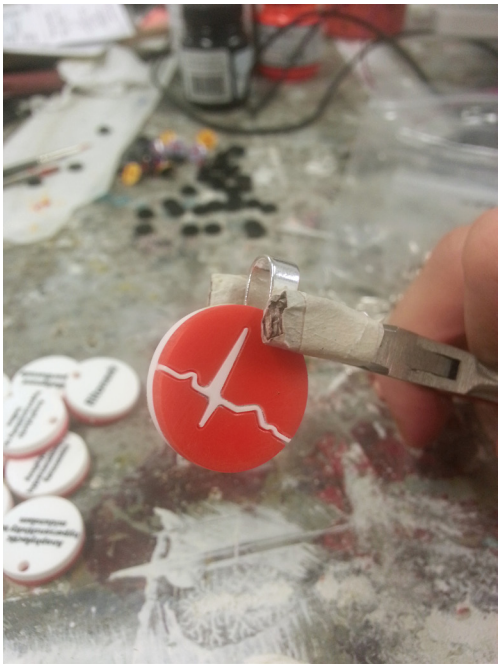

Jacquard
TEXTILE
COLOR

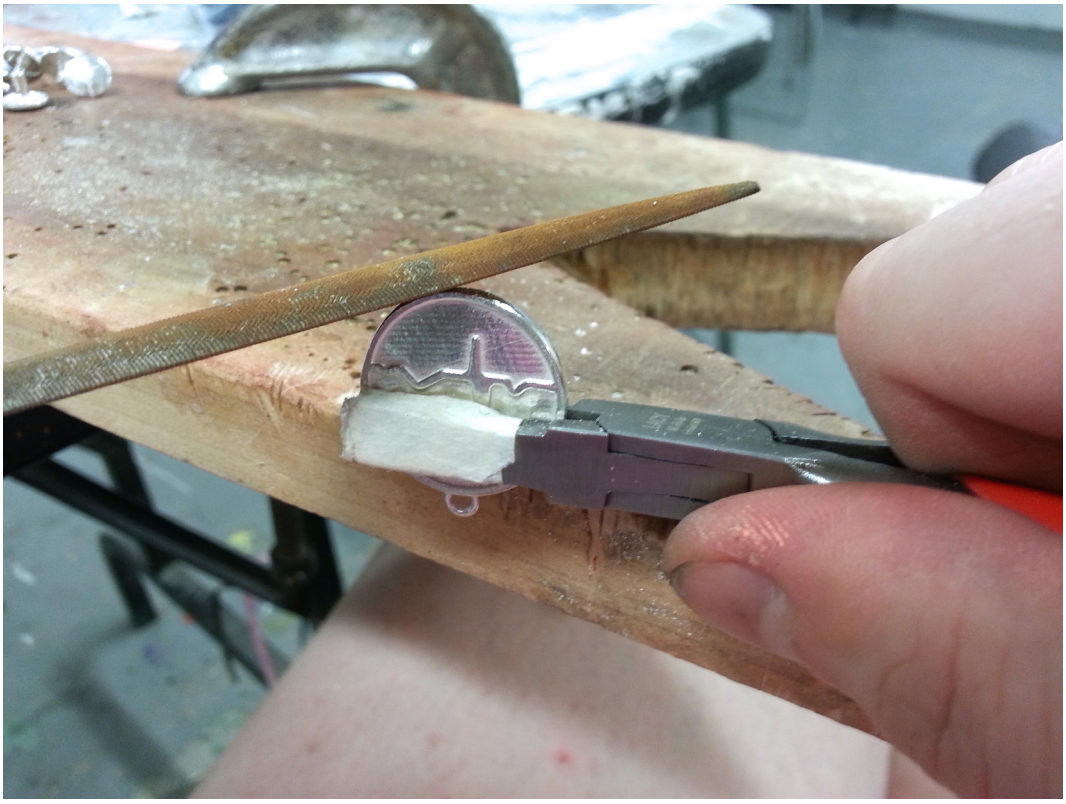


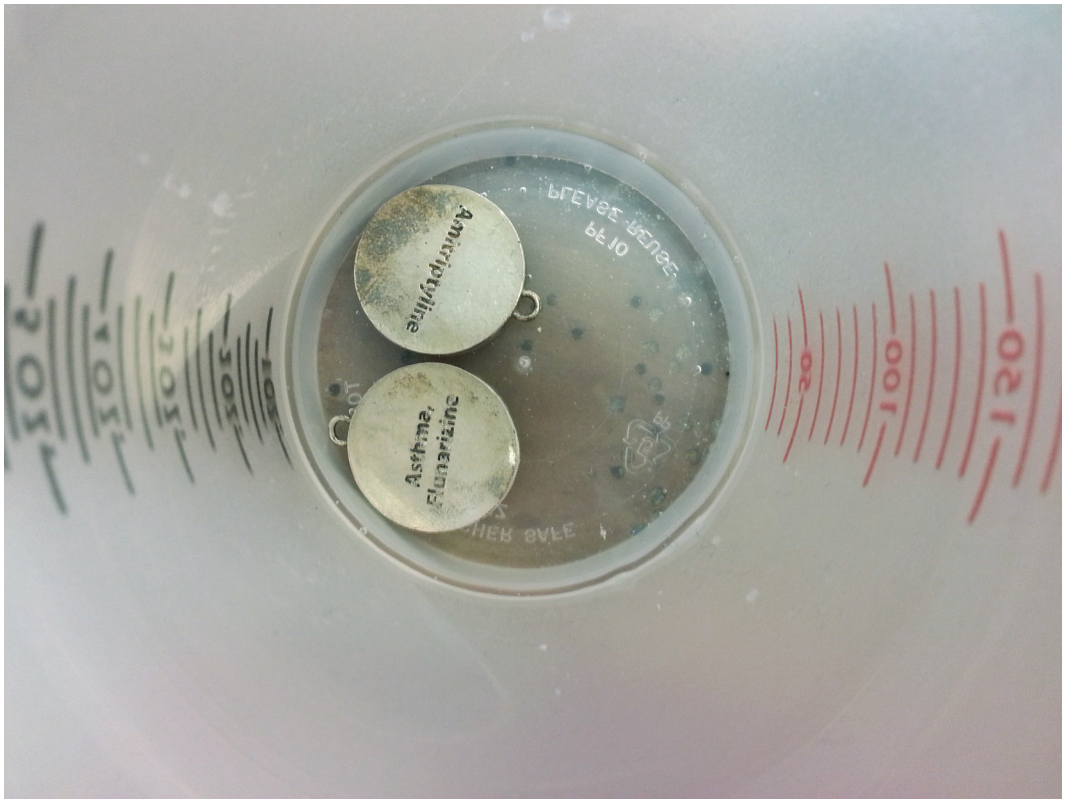




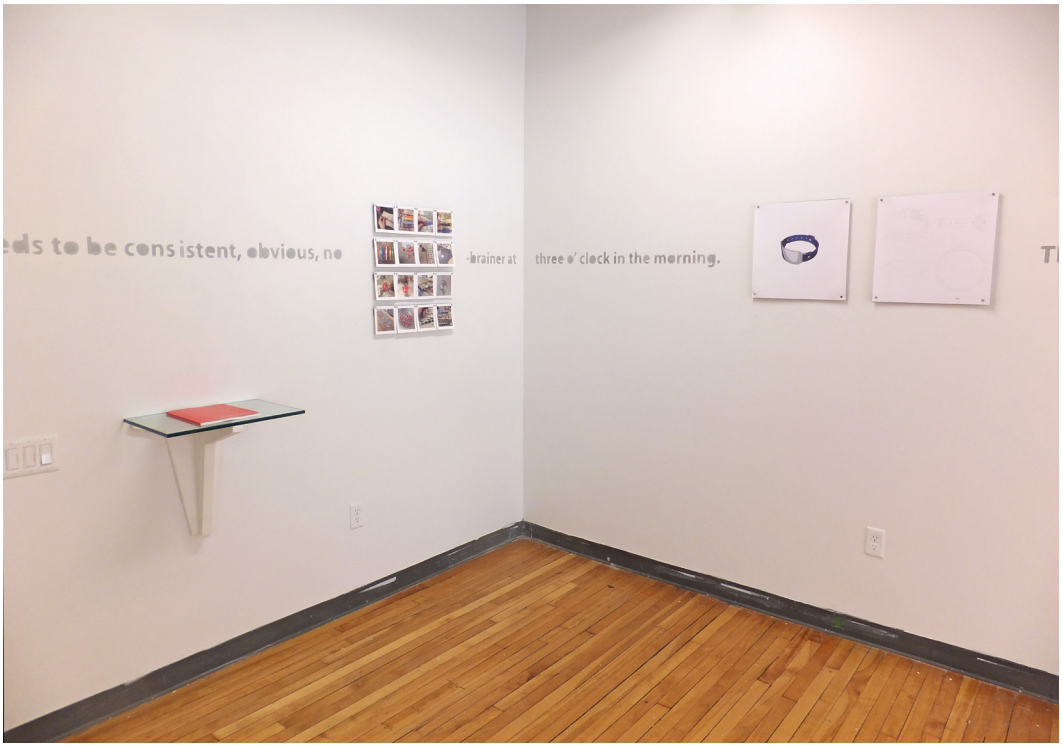


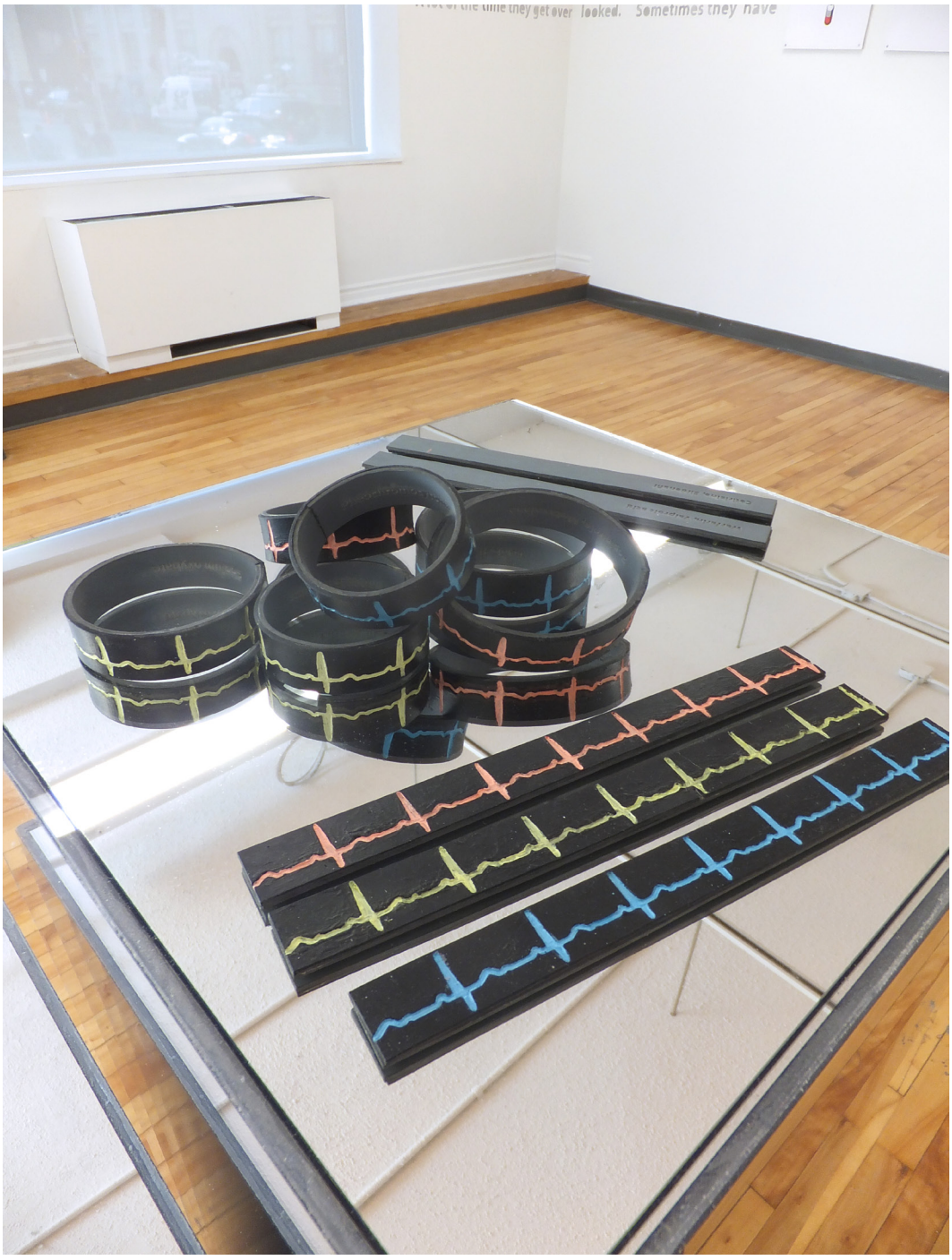





Amitriptyline
Asthma
Pulmonaire

Appendix C.
Documentation of graduate exhibit




looked. Sometimes they have


tion on them that we don't need. From
your medication list alone I can usually figure out
medical history.


Myasthenia gravis
Amitriptyline
Myasthenia gravis
Entscapone
Asthma, Fluoxetine
Phenytoin
Arsenic trioxide
Fluvoxamine


Family name: Robinson
Given names: Daniel Martin
Cardiomyopathy, eplerenone
Sirolimus
Addison disease


f the time they get over looked. Sometimes they have
a lot of information on them that we don't need. From