The User Interface of a Medical First Aid Application
A Close-to-Realistic Usability Study with the Smartphone Application "Defi Now!"

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Abstract: Several smartphone applications are available to support the delivery of medical *first aid*, in particular *cardiopulmonary resuscitation (CPR),* by untrained people. These apps support passers-by witnessing an emergency situation, or enable brushing up basic knowledge of first aid. Moreover, they inform about publicly available *automatic external defibrillators (AEDs)* and allow users to add the location of new devices. In this paper, we describe features of various first aid apps currently on the market. In order to find out whether or not these apps can really be helpful in emergency situations, we conducted a usability study with 74 participants who used the "Defi Now!" app. In order to simulate "realistic" conditions where the user is agitated—as is the case when rescuing a person suffering from cardiac arrest—we induced fear by a psychologically recommended method. Based on data from a questionnaire and video recordings, we discuss strong and weak points of "Defi Now!". The app was judged to be very helpful for medically untrained people. Nonetheless, our observations suggest several improvements to the user interface.

1 INTRODUCTION

According to the Federal German Health Information System (http://www.gbe-bund.de), sudden cardiac arrest due to ischemic heart disease is the most common cause of death in most Western countries, and a major cause of hospital admissions. In the U.S., the number of deaths due to Sudden Cardiac Death exceeds 250,000 annually.

In case of cardiac arrest, immediate help is essential and defibrillation is mostly inevitable; to this purpose, *automatic external defibrillators (AEDs)* are currently provided at many public places. Average survival rates of 30% for defibrillation by first responders within 3 to 5 minutes are reported by http://www.heart.org/HEARTORG/. The chance of survival decreases by 10% per minute when no help is provided (e.g., Cummins et al., 1985). Hence, everybody who owns a feature phone or smartphone is obliged to call for help on site. Moreover, passers-by should administer *first aid*, especially *cardiopulmonary resuscitation (CPR)*—a procedure helping to restore blood circulation and to preserve intact brain function—, when a person is suffering from cardiac arrest or shows no vital signs. CPR (either performed as compression-only without mouth-to-mouth or with mouth-to-mouth respiration) is a manual treatment, indicated until further treatment, such as defibrillation, is available.

But in such a precarious situation, the *bystander-effect* (Darley and Latané, 1968) is more likely to be observed than immediate help, i.e. the phenomenon that, in case of an emergency, individuals are less willing to offer help the more bystanders are present. This diffusion of responsibility results in waiting for someone else to take command. Furthermore, bystanders tend to belittle the existing emergency since no one has intervened so far. Thus, they judge that no emergency is at hand and help is not necessary. The most common cause for the denial of assistance, however, might be the fear to fail or to be ridiculed. This fear discourages many people to help, especially when they are unable to judge the gravity of the situation (e.g., Jörg, 2012). To what extent can a smartphone application (app) help passers-by not to become bystanders but rescuers?

In the next section, we summarize desirable features of existing *first aid smartphone applications*. In order to find out whether or not these apps can really be helpful in an emergency case, we investigated the usability of the "Defi Now!" app with 74 participants. In order to simulate the stress that is

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typically experienced by untrained individuals who are helping a person suffering from cardiac arrest, we applied *induced agitation*. In Section 3, we present the results of our study. Basically, the app was judged to be very helpful. However, our observations during the experimental sessions suggest several software-ergonomic improvements in support of the rescuers (cf. Section 4). In Section 5, we draw conclusions and address future work.

2 FIRST AID APPS

A search for "first aid" applications in the markets *Google play* and *ITunes* of the two main operating systems for smartphones yields more than 1,000 applications. However, this number includes entertainment applications such as a gamers' guide for "World of Warcraft". Here, we list six apps that focus on first aid in case of cardiac arrest and are available in Austria, France, Germany, Switzerland, or the United States:

- *Defi Graz* (www.madison.at (Austria); interface only in German);
- *Arrêt Cardiaque 2.0* (www.associationrmcbfm. fr (France); multilingual interface);
- AED Locator (www.aedlocator.org (Germany); in German);
- *Defi Now!* (definow.org (Germany); multilingual interface);
- *Herzsicher* (www.herzsicher.ch (Switzerland); in German);
- *PulsePoint* (pulsepoint.org (United States); in English).

First, we outline the main features of "Defi Now!" (Lange, 2011), the system we evaluated in our study (Section 3). Then, we complement the list of desired features with *best practices* from the other apps, and recommend improvements that can yield an optimal interface for a cardiac arrest first aid app (Section 4).

The interface language of "Defi Now!" is automatically adjusted to the user's phone settings. For example, if the user has chosen English as preferred language, the app appears in English as well. When opened, the app displays three options:

1. Emergency call;
2. First aid measures;
3. Find an AED.

Pressing the button "Emergency Call" automatically activates the national emergency phone number adapted to the user's whereabouts. However, the button does not immediately dial the emergency number because the rescuer has to confirm first by pressing "Yes" in response to the question whether they actually want to place the emergency call—in order to avoid hoax calls.

While placing the call, the current address is displayed to the user so that foreigners (and nervous rescuers) can easily provide the location's precise address (in Germany, GPS data are not automatically sent).

By pressing the button "First Aid Measures", first aid procedures are displayed in the form of diagrams (Figure 1), separately for patients showing vital signs (right branch from topmost node) and patients showing no vital signs (left branch).

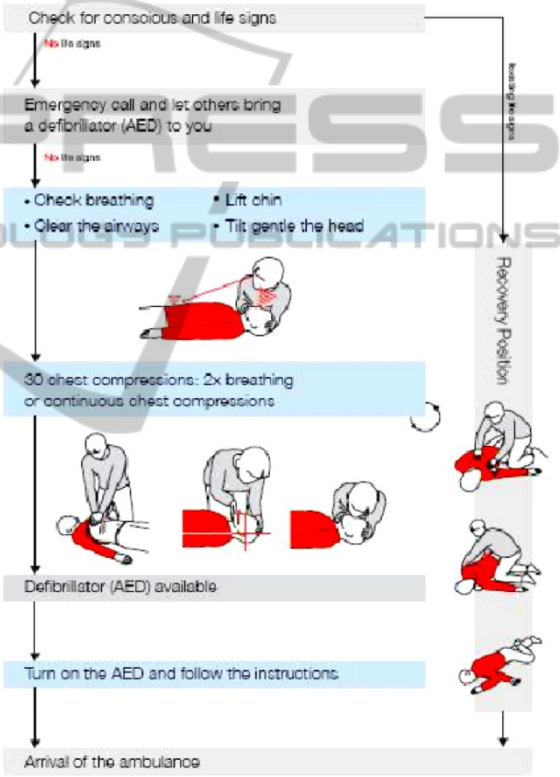


Figure 1: "Defi Now!" guideline for administering first aid.

If the patient shows no vital signs, the rescuer receives information on how to perform *cardiopulmonary resuscitation (CPR)*. A metronome provides audio support for a resuscitation beat of 100 times per minute, with an option to administer mouth-to-mouth/nose respiration. The user selects the desired action by scrolling to the bottom of the page, where two options are presented (see Figure 2): pressing a text button, which activates the standard rhythm of 100 beats per minute, or pressing a settings wheel. The latter option enables the user to choose the arti-

ficial respiration option, which activates a spoken command telling the rescuer when to breath (two times breathing after every sequence of 30 beats).

Figure 2: Select the metronome beat and the setting for artificial respiration.

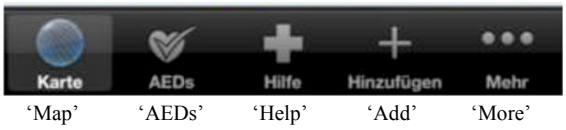
Activating the third item of the opening screen by pressing the button "Find an AED" enables the search for AED locations on an interactive map. Four types of icons may appear (cf. the pins in the center of the left panel of Figure 6):

1. A red cross on white background indicates a place where medical staff is available;
2. Green lightning icons denote verified AEDs;
3. Grey lightning icons stand for still unconfirmed AEDs;
4. Blue lightning icons refer to AED locations retrieved by the database "AED-Kataster".
   In order to update this database, the user can add a new AED device (not discussed here due to space limitations).

Now, we sum up desirable features present in the abovementioned apps but not in "Defi Now!". Several other systems (e.g. "Herzsicher" and "PulsePoint") provide a *tab(ulator)-based interface* (see Figure 3), where all available functions are permanently visible/selectable. This dialogue style avoids error-prone search for, and navigation to, the desired menu item. Therefore, in our study, we evaluate how easy it is for "Defi Now!" users to deal with non-tabulator-based navigation.

"Defi Graz" and "Arrêt Cardiaque 2.0" support first aid in a more *graphical manner* (see Figure 4) that might be easier to follow than a more textual instruction such as in "Defi Now!". Therefore, in our study, we asked the participants how comprehensible they found the instructions given in the diagrams.

All non-German systems allow for easier emergency call functions due to *automatic location* of the smartphone.



'Map' 'AEDs' 'Help' 'Add' 'More'

Figure 3: Top-Level Choice Menu in "Herzsicher" Exemplifying a Tabulator-based Interface.

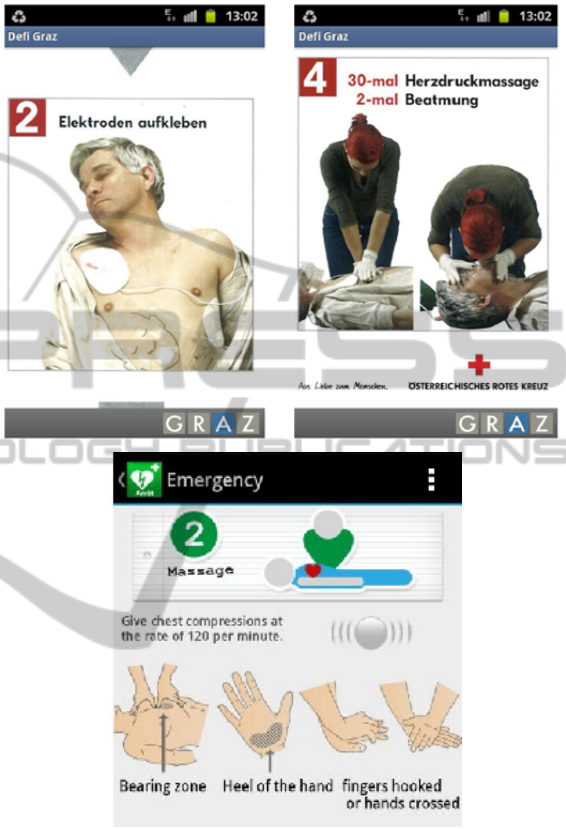


Figure 4: Upper panel: Graphically supported first aid instructions in "Defi Graz"; Lower panel: CPR details in "Arrêt Cardiaque 2.0".

"Arrêt Cardiaque 2.0" provides *social-network integration*. The app may be connected with the user's Facebook and/or Twitter account to share the AED they registered with their network. The integration of social media might serve as a fast way of distributing information about AEDs to a great number of users. Hence it might promote public awareness of this important information. The more people are aware of such critical issues, the greater the likelihood they also want to learn how to act in an emergency instead of functioning only as bystanders.

In "Arrêt Cardiaque 2.0" and "PulsePoint", users can register as *first responders*. If a cardiac arrest occurs in the vicinity of a first responder, this person is sent a notification in case of a cardiac arrest near-

by. For example if a cardiac arrest occurs in a shopping center, it might be possible that a subscriber of such an emergency notification may be in the same building or in the neighborhood. In "PulsePoint", the thus alarmed rescuer receives a route description to the location of the patient.

"PulsePoint" provides additional functionality for emergency situations other than cardiac arrest. Via a tab labeled "Incidents", the user can ask for an overview of all fire department emergencies occurring at the current moment. A "Photos" tab provides a photo gallery of major incidents from firedepartment.org. Users may scroll through the gallery and select photos they want to view. A "Radio" button enables a streaming radio feed from the dispatch center of the fire department.

3 THE USABILITY STUDY WITH DEFI NOW!

Some of the features we outlined above (e.g., graphics) are obviously very suitable to make a first aid app supportive for a rescuer. However, more detailed insights into unexpected problems require a *usability study* (see, e.g., Nielsen, 1994).

3.1 Method

The participants were tested in individual sessions. They were seated at a desk, with an iPhone 3GS (iOS 6.0.1) with the preinstalled "Defi Now!" app in front of them, and carried out the tasks listed in our questionnaire (see Section 3.2). Their actions were recorded via a camcorder (Plawa DV-4 SD-Camcorder; image resolution 4.0 MP), which was focused on the iPhone's display, thus ensuring anonymity of the participants. The videos were used to reconstruct the handling of the application, and to survey the errors made during task execution.

We tested 74 participants, 35 female and 39 are male; for their age distribution, see Figure 5. Nine of them had been, or still were, students of computer science at our campus, where we had run a pilot study in an observation lab. Another eight participants were doctors or qualified medical employees. The other 57 participants had different occupations, such as fitness trainer, banker or steel mill worker. Four participants had experienced a heart attack themselves before; one of them even had suffered from a sudden cardiac arrest and had to be resuscitated. All but the students were recruited as patients in the waiting room of a doctor's office or as customers of a fitness center where we had reserved a separate room to perform the experiment.

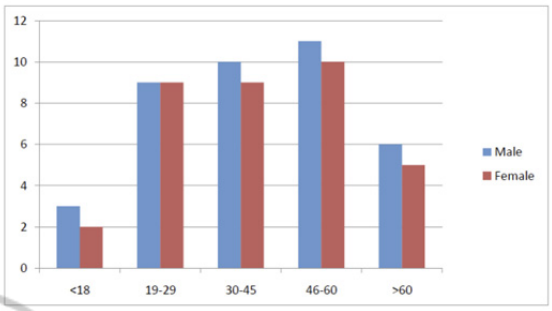


Figure 5: Age and gender distribution of the participants.

When witnessing an emergency situation such as cardiac arrest, bystanders and rescuers usually show signs of emotional stress, for example trembling hands. In order to simulate this stress, we applied a psychological technique to induce agitation (see, e.g., Otto, 2000). Watching a short sequence of a movie can elicit high levels of agitation in test participants due to the high attention and the intensive experience tied to watching a film clip (e.g., Gross and Levenson, 1995); (Hewig et al., 2005); (Schleicher, 2009). For our experiment, we selected a film clip from the movie "The Shining" (1980), showing a playing child who heads towards a closed hotel room door. The viewer gets the feeling that something terrifying is lurking behind the closed door (see also Hewig et al., 2005 on this fragment).

In order to study the effect of agitation, a random selection of 54 of our participants watched the film clip before using the app. The remaining 20 participants functioned as a control group and did not view the film clip. Age, gender, ethnic background, etc., distributions in the two groups were comparable.

3.2 Questionnaire

The initial section of our questionnaire consisted of questions concerning factors known to influence precision of task execution (cf. Schleicher, 2009). The participants had to state their personal condition with respect of discomforts (e.g., high blood pressure and/or use of medication). Moreover, they labeled their emotional state (*Happiness, Grief, Fear, Disgust,* or *No Emotion)*. They could also add a label for the emotion they experienced if none of the predefined ones matched. Additionally, they stated their personal condition as *good, relaxed, nervous, anxious, tired,* or *ill-tempered*.

The next part of the questionnaire consisted of nine tasks, covering all features of the application

"Defi Now!" to be carried out during the test. After each task, the participants had to judge the presentation of a given task by means of a five-point rating-scale, ranging from *1="not understandable at all"* to *5="completely understandable"* (cf. Rohrmann, 1978). Moreover, they could spontaneously mention what they (dis-)liked about the task. For each of the individual tasks we measured the time it took to perform them.

The last part of the questionnaire consisted of various general questions to the participant: Whether they owned a smartphone themselves; whether they find spoken instructions in the app helpful, especially with respect to administering first aid. Furthermore, they were asked whether/when they attended their last first aid course, and whether they judged a first aid app useful in case of emergencies such as cardiac arrest.

3.3 Results

As regards the influence of stress, we could not observe any significant effect on the execution of the "Defi Now!" tasks. This is in spite of the fact that the film clip induced emotional states comparable to those reported by Schleicher (2009). In our study, 17% indicated they did not feel any emotion while watching the clip. However, the intended emotion was evoked in 70 % of the participants. We found no significant differences between the student group, the medically trained personal and the other participants. They all had similar problems with the same features of the user interface.

Let us first describe the answers to the questions about personal factors with influence on precision of task execution. With respect to their physical condition, 84% declared they did not suffer from any health problems. From the 16% who mentioned health problems, one participant used tranquillizers, two had a common cold, five are high-blood-pressure patients and three had problems with their cervical spine. Analysis of the video data and the participants' behavior, lead to the conclusion that some discomforts as well as specific medication could affect a person's performance. The participant who used tranquillizers, for example, seemed distracted and agitated. Those who suffered from hypertension did not show signs of nervousness. However, the physical condition of a participant had no influence on their emotional state.

With respect to their current emotional state, 59% stated they felt good, 15% stated they were relaxed and 14% were nervous. Five participants (7%) declared they were tired and another two felt anxious (3%). None of the participants answered they were ill-tempered.

Now we sum up the observations recorded during performing specific task with the app. (Due to space, we focus here on first aid and finding an AED). When the test participants were asked to open the function "First Aid Measures" and to review the diagrams with first aid procedures, 57% stated that they knew which first aid step to perform next, at all times. Only 12% felt uncertain about possible next steps, 19% judged the diagrams as unsuitable and wanted more detailed instructions. On the other hand, 64% declared the diagrams suitable for learning, since they immediately understood the proper sequence of first aid procedures to be carried out in case of an emergency.

When asked whether they saw the circular symbol in the diagram (cf. the lower right corner of the box in the middle of the diagram in Figure 1), 64% of the participants denied. 21% searched for the mentioned symbol on request and found it after an average of 7.6 seconds. Merely 16% of the participants had detected the circular symbol spontaneously. (Notice that the circle indicates the need to execute the corresponding measure repeatedly; without repetition, CPR is ineffective.) Twelve participants stated here that they would appreciate spoken statements or a combination of speech and graphics/text. Eight participants criticized the wording used in the diagrams. The medical term "Compressions of the thorax" was often judged as too technical. Seven participants stated they had rather seen more graphics and less text. One of them remarked that "assembly instructions guide primarily via graphics and not via text. If they would consist mainly of text, people would probably not read it."

Two of the participants who were doctors, commented that the diagrams did not indicate that the movement of the patient's head should be a reclination, not a rotation. (If this movement is not performed correctly, respiration cannot be performed effectively).

Nevertheless, the most salient point of criticism was the fact that the user has to exit the first aid guidelines when placing an emergency call. Six participants voiced the idea that the feature of placing an emergency phone call should be integrated directly into the diagram of first aid measures, possibly visualized as a button at the onset of these guidelines.

The App "Defi Now!" contains a metronome for the user to set CPR rhythm (number of thorax compression per minute) and CPR mode (with or with-

out artificial respiration). During this task, the users were prompted to activate the metronome's acoustic signal supporting the pace of thorax compressions, and then to stop the signal. This task proved to be error-prone. Only 32% of the participants recognized the trigger of the metronome immediately when they scrolled to the bottom of the diagram (cf. Figure 2). 41% had more difficulties and pressed the button predefining the resuscitation beat only after an average of 6.3 seconds. 5% initiated the beat after more than 10 seconds and 23% saw the trigger only after instruction. Overall, 58% expressed the desire for more directions given by the application itself. 47% suggested that the trigger should be placed at a different place, for example directly next to the graphics depicting the CPR procedure.

If not stopped manually, the metronome keeps producing the beats. When asked to stop the acoustic signal, 47% were able to fulfill this task within 3.2 seconds. Nevertheless 41% required 5 seconds or longer to pause the metronome. 65% criticized the button label shown while the metronome was active. While the beats go on, no label referring to stopping it is visible; instead, in case of artificial respiration, the button shows the number of beats passed by since the last breathing.

Several participants voiced misgivings regarding controllability, since it took them quite some time to find the trigger setting the resuscitation beat and then to stop it again. Some participants criticized that a user probably would not even expect a metronome to set the CPR rhythm, if they had not been made aware of the availability of this feature. Ten participants suggested highlighting the metronome trigger, for example by labeling it more clearly, giving it a different color or adjusting the button size.

One of the participants' tasks was to change the settings for CPR execution; that is, to indicate whether the 100 beats per second should be interrupted, after every 30 beats, by the spoken command to apply mouth-to-mouth respiration (two breathings: 30:2). 47% declared they immediately recognized the button referring to the setting of resuscitation beats (cf. Figure 2). 53% experienced difficulties fulfilling the task of changing the CPR mode (with or without artificial respiration). 26% of the participants held the opinion that this facility for alteration was not relevant, whereas 74% found it important. Six participants criticized that the settings button was insufficiently salient and desired a more obvious labeling, for example a written identification of the function of the button.

Three participants (medics) remarked that the duration of time scheduled for mouth-to-mouth respiration, which is set to three seconds, might not suffice because the rescuer has to change body position when starting artificial respiration. Several participants (medical personnel and laymen) remarked that the option to alter CPR mode might in fact be obstructive and counterproductive. They argued that a user might be overchallenged by the options of cardiac-only resuscitation vs. CPR with mouth-to mouth respiration. For them, a precise instruction preinstalled in the application would be preferable. One user opposed to the fact that the metronome stops as soon as the user quits the menu section "First Aid Measures" and, for example, returns to the map searching for an AED. The rescuer is unable to adjust CPR to the pace preset by the metronome while seeking an AED. They might also not be able to keep pace with the metronome rhythm, which might entail severe consequences, as stated before. (Other passers-by might happen to have the "Defi Now!" application installed on their smartphones, and activate the beat there.)

To sum up the findings regarding the second top-level menu item, the task of setting the CPR mode brought several problems to light concerning operability. Several participants were not satisfied with the implementation of features such as the labels on the buttons referring to the starting/stopping of the resuscitation beat and CPR mode. They evaluated these features as being not self-explanatory and expected clearer labels for better usability. Moreover they were not satisfied with the controllability since it took them quite some time to find the trigger starting the metronome settings—in about 70% of the cases it took more than 6 seconds to get the acoustic signal started. Many participants said that in case of an emergency, they would waste time searching for those specific functions, and remarked that these should be implemented in a more eye-catching and better comprehensible manner.

The test of the third top-level menu item "Find an AED" unveiled several unfulfilled user expectation as regards the user interface. The app shows either a tabular view or an interactive map, depending on which icon in the upper panel is selected (in the upper panel of Figure 6, see the highlighted buttons serving to switch between the two option). 41% of the participants stated they expected to find this function within the menu section concerned with adding a new AED location; 54% expected the tabular view under "Find an AED". Seven participants commented on the tabular-view button. In their opinion, a written labeling would have marked the

function clearer. Three participants voiced the idea that the tabular view might be displayed before revealing the map. This might facilitate the understanding of which AED location is the nearest, as indicated by the distance value.

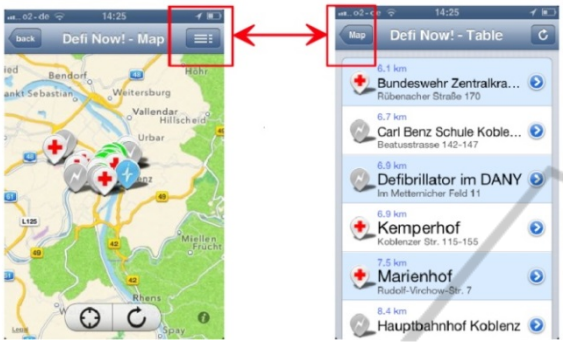


Figure 6: Switching map to list presentation of AEDs.

With respect to overall navigation, the app sometimes violated user expectations; e.g. the "Back" button occurs in the lower panel although it is usually located in the upper left corner (in iPhones). Unclear icons in unexpected positions increase operating time. An example is the "Information" button for the types of AEDs. Although the icon *"i"* in a circle is well chosen, its small size, its grey background color and its position in the lower right corner (see the left screen shot of Figure 6) made it unfindable to nearly all participants.

Due to space, we only address two questions from section 3 of the questionnaire here. 71% of the participants agreed that "Defi Now!" is appropriate when administering first aid in an emergency. However, 7% stated that the app might distract inexperienced users who are unfamiliar with the app. Thus, eliciting interest in first aid procedures without the stress elicited by the emergency situation is an important issue.

Familiarity with first aid procedures did not correlate with execution time of the tasks—opposite to what one might have expected; according to the questionnaire, 2 test subjects had never taken any first aid course; 25 had followed a course less than 3 years ago; 11 less than 10 years ago; and, 35 participants more than 10 years ago.

4 OPTIMIZATING THE USER INTERFACE

Based on our user study with "Defi Now!" and best practice in other smartphone apps, we recommend some easily attainable improvements for a first aid user interface and illustrate them with mock-ups.

In view of German law, the installation dialog could ask the user, as soon as the system has been loaded, for permission to localize the smartphone; this would provide for automatic emergency calls (of course, after confirmation by the user). This feature would also enable automatic route descriptions to the next AED automatically, as in PulsePoint. The app "Arrêt Cardiaque 2.0" suggests another very desirable feature. "Defi Now!" should be embedded in social network environments so that knowledge about its availability can spread faster and wider.

In order to highlight all available functions, we propose a three-part start menu (see Figure 7) where the "Emergency mode" button is pre-selected as default in order not to waste time selecting it under time pressure. The second item can be an "Exploration mode", inviting smartphone owners to try out and to learn about first aid and nearby AED locations in their spare time. The possibility of adding new AEDs can become more prominent when it is listed in the start-up menu (as third item).

Figure 7: Mock-up of the start menu.

Given the observed confusion when navigating, we propose a tab-based surface (Figure 8) as used in several other first aid apps (Section 2). Red color indicates which tab is currently active. Moreover, the emergency call tab (which in Germany is 112—but should be adapted automatically to the user's current whereabouts) could become grey after being used once.

The way first aid measures are presented could receive better graphical support (as in Figure 4) and be underpinned with spoken instructions (to be activated, for instance, by touching an image in the overview). This issue should be worked out in collaboration with medical experts in order to avoid

ambiguity in the provided images and to select the best CPR mode (e.g., based on survival rates reported in a study by Bohm et al., 2007). Crucially, the CPR instructions should be visible permanently together with a nearby change-mode button. Alternatively, the two CPR modes could be directly associated with the CPR box in the diagrams, recognizable as push buttons (see the grey areas with loudspeaker symbols in Figure 8). Switching audio on and off should be possible in a way familiar to many prospective users.

Figure 8: Mock-up illustrating always-visible tab-navigation and improved first-aid diagrams.

5 CONCLUSIONS

We have outlined the functionality provided by various apps aiming to support the delivery of first aid to persons suffering from cardiac arrest, in circumstances where immediate help is essential and defibrillation is virtually inevitable. We reported the results of a close-to-realistic usability study with the German “Defi Now!” app. Most of the participants estimated that the app would be helpful in emergency cases. We recommended some improvements based on best practices in various other first aid apps and on our own observations during the usability study.

First aid apps can increase their usefulness if they offer easily accessible opportunities for learning and exploration. They should enable smartphone owners to refresh their knowledge of first aid measures, thus being better able to administer first aid spontaneously when witnessing an emergency. As for future work, this suggests the development of first aid training apps that invite to dry-run first aid procedures in a challenging manner.

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