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Original Reports

Development and Testing of Painometer: A Smartphone App to Assess Pain Intensity

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Abstract: Electronic and information technologies are increasingly being used to assess pain. This study aims to 1) introduce Painometer, a smartphone app that helps users to assess pain intensity, and 2) report on its usability (ie, user performance and satisfaction) and acceptability (ie, the willingness to use it) when it is made available to health care professionals and nonprofessionals. Painometer includes 4 well-known pain intensity scales: the Faces Pain Scale–Revised, the numerical rating scale–11, the Coloured Analogue Scale, and the visual analog scale. Scores reported with these scales, when used in their traditional format, have shown to be valid and reliable. The app was tested in a sample of 24 health care professionals and 30 nonprofessionals. Two iterative usability cycles were conducted with a qualitative usability testing approach and a semistructured interview. The participants had an average of 10 years' experience in using computers. The domains measured were ease of use, errors in usage, most popular characteristics, suggested changes, and acceptability. Adding instructions and changing format and layout details solved the usability problems reported in cycle 1. No further problems were reported in cycle 2. Painometer has been found to be a useful, user-friendly app that may help to improve the accuracy of pain intensity assessment.

***Perspective:** Painometer, a smartphone app to assess pain intensity, shows good usability and acceptability properties when used by health care professionals and nonprofessionals.*

***Key words:** Pain intensity, assessment, mobile app, smartphone, usability testing.*

Over the last 2 decades, significant advances have been made in the assessment of pediatric pain. One important development has been the integration of electronic and information technologies (EITs), particularly web-based systems and mobile handheld devices. EITs have a number of advantages when assessing pain in young people, such as greater accessibility,[8,9] improved compliance,[1,7] and minimization of recall bias because data are collected in real time.[22] Children report greater satisfaction with[21-23] and preference for these EIT-based devices than the traditional paper-and-pencil format.[3,4,26] Generally speaking, available studies show that children learn easily[25] and have no difficulties using these EIT-based devices.[15]

Nowadays, an increasing number of smartphone apps claim to be of value in assessing different pain domains. Nevertheless, most of their properties have not undergone any validation or empirical analysis.[24] For example, although electronic pain diaries using real-time data capture might be able to improve compliance and ensure reliability and validity, their usability, feasibility, acceptability, and psychometric properties must be tested in patients and health care professionals before recommending

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widespread use. Of particular importance is the influence of age and developmental stage issues.

The aims of this study are to 1) describe the purpose and functionality of Painometer, a smartphone app that helps users assess self-reported momentary pain intensity, and 2) report its usability and acceptability properties when made available to health care professionals and non-professionals (children, adolescents, and young adults).

Methods

A Brief Description of the App and Its Development

Painometer is a smartphone app that contains 4 pain intensity scales: the Faces Pain Scale–Revised (FPS-R),[5] the numerical rating scale–11 (NRS-11), the Coloured Analogue Scale (CAS),[10] and visual analog scale (VAS). Settings and instructions are available in Catalan, English, French, Portuguese, and Spanish. These scales have satisfactorily been used with children and adolescents,[19] adults,[2,12] and the elderly,[11] and thus it could also be implemented with these populations when appropriate.

Written permission for using 2 of the scales (CAS and FPS-R) was requested and obtained from the authors and copyright holders. The other 2 scales (NRS-11 and VAS) are not copyrighted or authored, so no permission was required. The resulting app is free for academic and research purposes.

There are 2 approaches to developing mobile apps: native technology and web technology. Painometer is powered by the latest web technology: html5, css3, and JavaScript. It uses a JavaScript framework called Sencha.[27] It should be pointed out that a desktop app written with web technology is not necessarily a web app. Painometer is not executed in a web server but in the device itself. The visual interface of the app is shown via a web browser, and the app can also be used without an Internet connection once it has been installed.

Any device with a web browser can use Painometer. It is compatible with iPhone, iPad, and Android-based devices. It can also be used in a web page as an embedded "gadget" (eg, YouTube videos). Painometer can be used in 3 different ways: 1) face-to-face: a health professional, such as a nurse, shows the scales to patients, provides explanations, and records their self-reported pain intensity; 2) self-administered: people with pain can keep a record by downloading the app to their device; and 3) programmatically: as an extension of another app, Painometer can be used as a web gadget and extended to third apps. For example, it can be used as a gadget in an electronic pain diary.

The identification of Painometer users is not possible through collected data; the data are only used to show a temporal chart of pain intensity records. Users may share the data by sending the information to an e-mail address of their choice. Painometer does not use the data in other terms (ie, neither accessing nor collecting data from other apps in the device is allowed; uploading or collecting data to an external server is not possible either).

The first version of the app is shown in Fig 1.

Usability and Acceptability Testing

As defined by Schoeffel,[16] "usability is the effectiveness, efficiency and satisfaction with which specific users can achieve a specific set of tasks in a particular environment" (pp. 6–7). The usability objectives for Painometer are that the app is 1) easy to learn, 2) error-free, and 3) liked by the user. Because it is fundamental that the testing be conducted with end users, health professionals and children, adolescents, and young adults, as

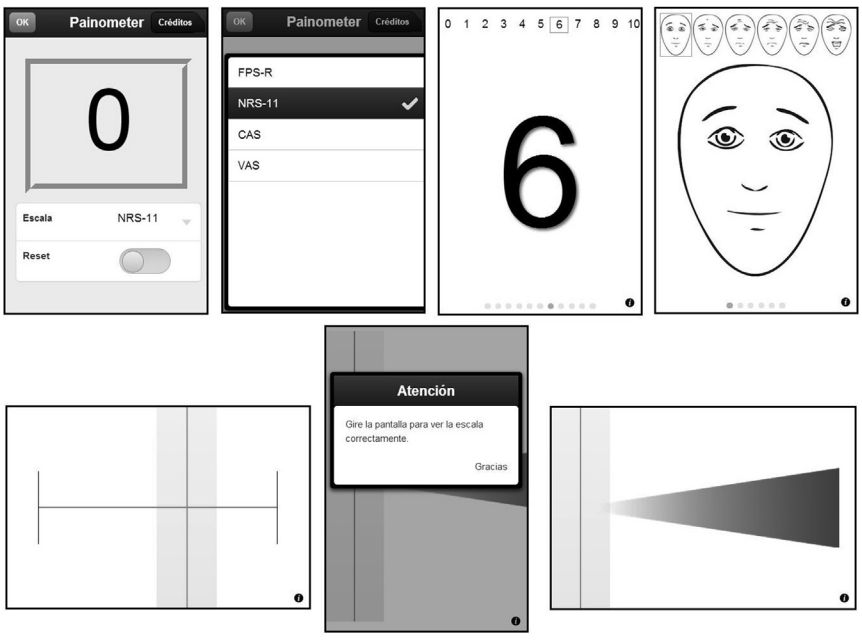

Figure 1. Screenshots of the different parts of the original Painometer.

potential patients, were recruited for the usability tests. The design was based on the concept of a "hermeneutical circle" as described by Snodgrass and Coyne,[17] which is an iterative process of implementing a design, learning and understanding from discussion and feedback, and making subsequent design refinements.

Professionals were also requested to report on their acceptability, that is to say, the extent to which they preferred the Painometer rather than the traditional paper-and-pencil way of assessing patients' pain intensity.

Phase 1: First Usability Cycle

Participants

A convenience sample of 19 health care professionals (53% female) and 14 nonprofessionals (57% female) participated in this phase of the study. It has been found that testing with 5 users is enough to detect 85% of the usability problems, whereas testing with 15 users detects 100%. Therefore, it is suggested to have at least 3 participants in each group when different groups are tested.[14] Health care professionals (mean age = 31.2 years, standard deviation [SD] = 16.9) were eligible if they were able to speak and read Spanish or Catalan. Nonprofessionals (mean age = 17.9 years, SD = 4.9) were eligible for the study if they were between 6 and 24 years of age, had experienced pain over the last 3 months, and were able to speak and read Spanish or Catalan. The nonprofessional participants reported pain in the head (n = 4), the abdominal region (n = 6), the legs (n = 2), the cervical region (n = 1), and the pelvis (n = 1). Participants would have been excluded if they had any major cognitive or psychiatric disorders or severe hand deformities that would prevent them from using the app. None of those volunteering to participate had to be excluded. Additional details are shown in Table 1.

Procedure

Participants were first informed of the purpose, risks, and procedures of the test, and they (or their parents if they were minors) were requested to sign an informed consent document to participate. A qualitative usability testing approach with a semistructured interview, adapted from the study by Stinson et al,[20] was conducted.

Standardized instructions on the use of Painometer were given to the participants. Health care professionals were asked to use Painometer as if they were using it with a patient. If they did not have any experience in using pain intensity scales, they were taught to do so with paper-and-pencil versions of all the scales before using the app. To assess acceptability, they were also asked whether they preferred to use Painometer or traditional paper-and-pencil scales.

Nonprofessionals were requested to report the maximum pain intensity they experienced in the last 3 months. All participants were asked to "think aloud" while using the app (ie, changing between screens, assessing pain intensity with the 4 scales, reading the main menu, etc). Field notes were taken and the mistakes made by both groups were recorded. "Major usage errors" were recorded when participants got stuck in any screen of the app or were unable to do the requested tasks, whereas "minor usage errors" were registered if they hesitated in doubt or touched the wrong buttons but were finally able to do the tasks successfully.

After completing the requested activities, all participants were asked 7 open-ended questions about ease of use, efficiency, and their satisfaction using Painometer. They also filled in a questionnaire about their previous use of technology; the questionnaire was adapted from the one developed by the Society for Technical Communication "Usability and User Experience Resources" webpage[18] and is available on request from the authors.

Analysis

The quantitative data from the interview were analyzed using SPSS Statistics 20 for Mac (http://www-01.ibm.com/software/analytics/spss/; IBM Corp, Armonk, NY) to determine measures of central tendency and the distribution of values. Field notes were taken and transcribed in text format. Simple content analyses were conducted to determine the users' satisfaction and problems with the categories emerging from the usability research questions.

Results

The professionals had an average of 12 years' experience in using computers, whereas the nonprofessionals had 8 years' experience. The professionals had been using smartphones for an average of 1 year and the nonprofessionals for 1.5 years.

Table 1. Sample Composition of Cycle 1

Professionals		Nonprofessionals	
Specialty	n	Age Group	n
Nurses	3	Children (8–12 y)	2
Physicians	3	Adolescents (13–18 y)	6
Physicians in training	8	Young adults (19–24 y)	6
Dental hygienists	1		
Psychologists	1		
Psychologists in training	2		

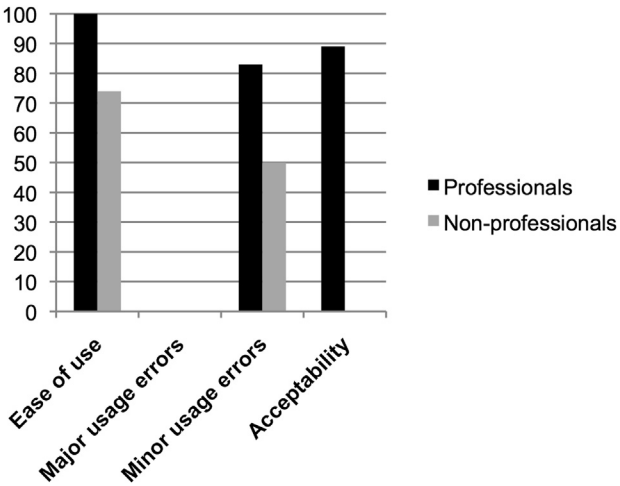

Figure 2. Main usability results of cycle 1.

Table 2. Sample Composition of Cycle 2

Professionals		Nonprofessionals	
Specialty	n	Age Group	n
Nurses	3	Children (8–12 y)	4
Physicians	5	Adolescents (13–18 y)	4
Psychologists	3	Young adults (19–24 y)	8
Psychologists in training	4		

Painometer was defined as easy, simple, intuitive, attractive, convenient, and useful when participants were requested to identify the characteristics that they liked the most. Most health care professionals (n = 18, 95%) preferred Painometer to the traditional versions of the scales; they stated that they would use the app as their first choice to assess patients' pain intensity. What nonprofessionals liked the most was that they could interact with the app by touching the screen. They had no major problems but did have some minor difficulties of usage related to the navigation menu and the orientation of the screen (see Fig 2 for details).

Changes to the App After Cycle 1

After analyzing the results of cycle 1, the following changes were made to the app: 1) A "guided tour" of the app was added: a short description of each element in the main menu emerges when the "?" button is pressed; 2) written instructions were provided for the scales: when a scale is selected, the usage instructions appear before the scale is displayed; 3) the configuration was simplified by a new screen navigation; 4) some device orientation issues were fixed.

Painometer was first developed in Spanish; then, the option to switch to the other 4 languages (ie, Catalan, English, French, and Portuguese) was added.

Phase 2: Second Usability Cycle

Participants

The inclusion-exclusion criteria were the same as in cycle 1; once again, none of those volunteering to participate had to be excluded. This time, the convenience sample of participants consisted of 15 health care professionals (mean age = 36.8 years, SD = 12.8; 53% female) and 16 nonprofessionals (mean age = 16.6 years, SD = 4.9; 67% female), none of whom had participated in phase 1. The nonprofessional participants reported pain in the head (n = 7), the abdominal region (n = 4), the legs (n = 3), and the shoulders and arms (n = 2). Sample composition is shown in Table 2.

Procedure and Analysis

All participants were instructed to use the app as in cycle 1 (see Fig 3 for details). The same kinds of analysis were conducted.

Results

The professionals had an average of 16 years' experience in using computers whereas the nonprofessionals had 6.5 years' experience. The professionals had been using smartphones for an average of almost 2 years and the nonprofessionals for 14 months. The most

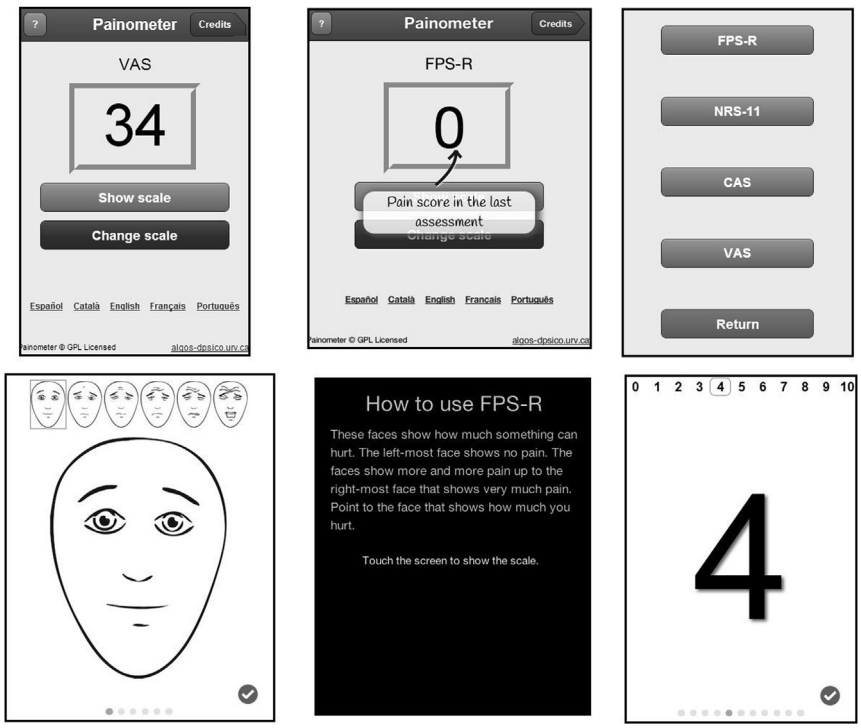

Figure 3. Screenshots of the improved Painometer.

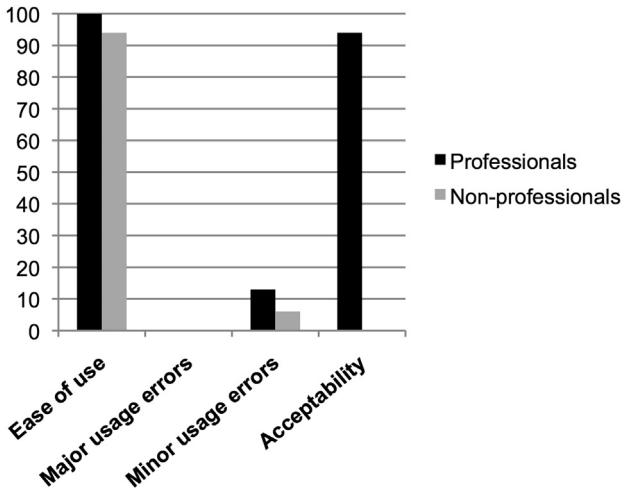

Figure 4. Main usability results of cycle 2.

popular characteristics of Painometer were its ease of use and that it was practical, attractive, useful, tactile, funny, and mobile-integrated.

Participants had no major problems using the app, although 3 of them (2 professionals and 1 nonprofessional) did have some minor difficulties of usage because of the size of the buttons and the space between them. Fourteen (94%) health professionals stated that they would use Painometer as their first choice to assess pain intensity (see Fig 4 for details).

When they were asked about possible improvements or changes, participants suggested 1) keeping a record of the data collected and 2) adding a graphic representation of pain intensity records.

Discussion

Painometer is an app that integrates 4 pain intensity scales. These scales have been tested in a wide number of studies with different pain samples and patients' ages, and the reported pain intensity scores, when using the paper-and-pencil version of the scales, have demonstrated to be valid and reliable. It is compatible with most smartphones and has been demonstrated to be a functional, usable, and acceptable smartphone app for assessing pain intensity levels.

The app had to undergo some changes after the first cycle; namely, a "guided tour" of the app was added, written instructions were provided for the scales, the configuration was simplified, and some device orientation issues were fixed. As shown by other studies,[20,21] 2 iterative cycles were enough to assess the app and to develop it to the satisfaction of potential consumers.

At this point, the suggestions about adding graphics and saving data were taken into account and new functionalities were included. Painometer enables the pain intensity records to be saved and sent by e-mail. It also shows a graph with the pain intensity data. Although the changes to the app (resizing the buttons) or additions (the function of sending pain intensity records by e-mail) made after the second usability cycle had not been tested, they are not complex and would rarely interfere with the app's use. They are also explained in the "guided tour" and in a "user's manual" that has been developed. Some screenshots of the final version of Painometer are provided in Fig 5.

The agreement between a verbal version of the NRS-11 and its electronic version as provided by Painometer has been recently tested in a sample of adolescents. We

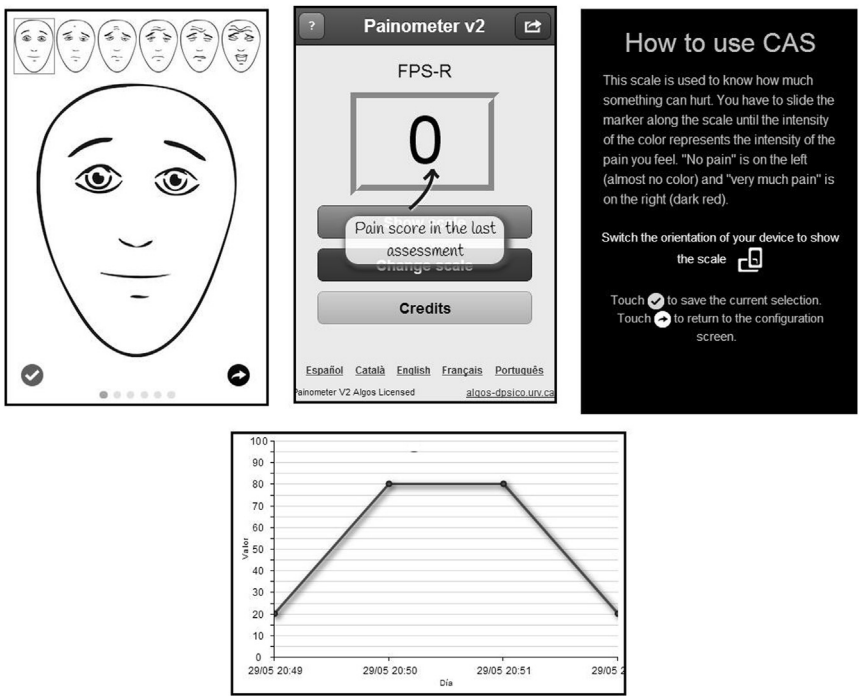

Figure 5. Screenshots of the final version of Painometer.

found that pain intensity ratings on the verbal and electronic versions are comparable.[1] Similarly, a study with adult chronic pain patients found that the scores obtained with an electronic version of the VAS are comparable with those obtained with the paper-and-pencil version of the NRS-11.[6]

Although e-diaries are starting to be popular among researchers, most of the existing measures for assessing pain intensity rely on recall and do not allow for prospective longitudinal assessment in naturalistic environments.[13] Painometer solves these problems because it is portable and makes momentary assessment possible, thus helping to avoid the memory errors of retrospectives measures.

Most professionals found Painometer easy to use and preferred it to paper-and-pencil scales, so it might encourage health care professionals to use psychometrically sound scales to assess pain intensity. Because of its simplicity and versatility, Painometer can help to better control acute and procedural pain and also to keep an accurate record of pain intensity.

A potential limitation of the study is that the usability of Painometer was tested in a single session. Some problems might arise when the app is used for a period of time; to address this potential issue, an e-mail address is provided within the app description, so users can contact the developers if a problem appears. Another limitation is that the English, French, and Portuguese versions had not been assessed during usability testing because the app content, instructions, screens, and layout were similar in all languages. However, there have been several downloads from English-, French-, and Portuguese-speaking countries (ie, Canada, n = 12; United States, n = 10; France, n = 6; Brazil, n = 5; and United Kingdom, n = 1), and we have not received any reports on usability problems, which might be considered as an indirect suggestion of proper functioning.

Painometer is available, for free, for research purposes and for clinical and/or educational uses. A user manual and the instructions to download the app for Android-based, iPhone, iPod, and other devices can be accessed following the link: http://algos-dpsico.urv.cat/en/painometer/.

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