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Computer Face Scale for Measuring Pediatric Pain and Mood

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Abstract

This investigation determined the psychometric properties and acceptability of an animated face scale presented on a hand-held computer as a means to measure pediatric pain and mood. In Study 1, seventy nine hospitalized, pediatric patients indicated their levels of pain by adjusting the expression of an animated cartoon face. The first objective was to determine feasibility, concurrent validity, and acceptability of the method. All patients were tested both with the Computer Face Scale and the poster format of the Wong-Baker Faces Scale. A second objective was to evaluate test-retest reliability of the method. In Study 2, fifty hospitalized, pediatric patients were tested on two occasions, but in this case the patients used the Computer Face Scale to indicate both their pain (how much they hurt) and their mood (how they felt). Children in Study 1 were able to use the Computer Face Scale to express relative amounts of pain/hurt; the method showed concurrent validity with the Wong-Baker Face Scale; and most children expressed a preference for the Computer Face Scale. The method also showed adequate test-retest reliability. In Study 2 adequate test-retest reliability was demonstrated for ratings of both pain and mood.

Perspective—The Computer Face Scale allows the health provider to obtain reliable and valid measures of pediatric pain and mood. The method can be understood and used by children as young as three years, and is also appropriate for use with adults.

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Keywords

pediatric pain; computer assessment; pain intensity; pediatric mood

Introduction

For many years, face scales have been used in the clinic to assess a child's pain intensity or the affect (unpleasantness) associated with pain.[13,14] Initially, these scales consisted of a small number of discrete faces intended to represent varying degrees of pain. The faces are either pictures of actual children in pain or are cartoon depictions of such. In both cases, a series of faces are presented together in a poster format, and children are asked to select the face that represents their current level of pain/hurt or unpleasantness.

More recently, there have been two major developments in this branch of pediatric pain assessment. The first development is the use of the computer to present face scales and record responses, and the second is the use of animated facial expressions spanning a range of alternatives that exceeds what is practical with discrete face scales.

Hicks and colleagues[8] developed an animated version of a static face scale by interpolating between a 6-point face series to create a 101-point face series. The latter series was then installed on a laptop computer so that adults (not suffering from pain) could select four faces to mark off equal intervals along the scale. Six discrete faces (including the two faces anchoring the ends of the scale) were selected by the investigators and later presented in a poster format for children to rate their pain. The main point of the investigation was to establish the psychometric properties of the static scale, rather than those of the animated scale. Goodenough and colleagues (www.usask.ca/childpain/research/6scales/6scales.pdf) later employed the same animated scale, along with several other common scales for assessing pain, and had children rate the intensity of their pain once during a hospital stay. There was high agreement among the ratings obtained by the different methods, but children judged the animated face scale to be the easiest to use. Similarly, in a study in which discrete faces were viewed sequentially on a hand-held personal computer,[3] it was reported that children preferred using the computer version over the poster version.

More recently, we have employed a laptop computer and developed software that allows the child to adjust the shape of the mouth of an animated cartoon face (smiling to frowning) while simultaneously changing the character of the eyes from completely open (associated with a smile) to completely closed (associated with a frown).[4] We found that children could use this method to express relative degrees of pain, and that children prefer using the computer method over the poster method.[20,21] We also found that the ratings from the computer method were significantly correlated with those from the Wong-Baker Faces Scale.

In the present investigation, consisting of two studies, we adapted our animated cartoon display for use on a hand-held computer which provides a more tractable means to obtain ratings of pain and mood from children in more types of clinical settings (e.g., while the child is in bed or walking around). The purpose was to explore this new format to determine (a) whether children can use the Computer Face Scale (CFS) to express their level of pain and mood as reflections of separate constructs (discriminant validity), (b) whether children prefer the CFS over the poster-version of the Wong-Baker scale, (c) whether the CFS demonstrates *concurrent validity* with the Wong-Baker scale, and (d) whether the CFS has satisfactory *test-retest reliability*. This work was originally presented in poster form at the annual meeting of the American Pain Society.[5]

Purpose

The investigation had four aims. The first aim was to determine whether children understood the link between the facial expressions of smiling and frowning and the subjective feelings of happiness and pain/hurt. The second aim was to determine whether children understood that relative degrees of smiling or frowning were linked to relative degrees of happiness and pain/hurt. The third aim was to determine the concurrent validity of the Computer Face Scale with the Wong-Baker Faces Scale presented in a poster format. The fourth aim was to determine the test-retest reliability of the Computer Face Scale when children rated both their current pain and mood.

Materials and Methods

Participants

In Study 1, the participants were a convenience sample of 79 inpatients (35 females, 44 males; mean age = 11.2 ± 3.9 years, range 3 to 17), undergoing treatment at one of three facilities: the Children's Hospital at Dartmouth, the Emergency Department at Dartmouth-Hitchcock Medical Center, and the Pediatric inpatient floors, Pre operative area of the Operating Room at Massachusetts General Hospital. A subset of 61 patients (31 females, 30 males; mean age = 11.2 ± 3.6 years, range 3 to 16) were tested twice.

In Study 2, the participants were 50 inpatients (25 females, 25 males; mean age = 11.0 ± 3.8, range 4 to 17) being treated at the Children's Hospital at Dartmouth Medical Center. The medical diagnoses of patients in both studies were varied (e.g., broken bones, infections, cancer), and the vast majority was or had been in acute rather than chronic pain. At the time of testing, some children were medicated, and some were not.

The work was approved by the Committees for the Protection of Human Subjects at Dartmouth-Hitchcock Medical Center and at Massachusetts General Hospital. Inclusion criteria were ability to use a stylus, fingers or thumbs to press 'up' and 'down' arrows displayed on the hand-held computer. Exclusion criteria were individuals 18 years of age or older, or any child with a mental or physical disability which precluded their understanding or performing the task. Written parental permission was obtained as well as verbal assent from the child. Each child was given a $15 gift certificate at Massachusetts General Hospital and a sticker for the younger children tested at Dartmouth-Hitchcock Medical Center. Older children at the latter site were not given any financial remuneration.

Procedure

The assessments were completed on a hand-held Dell computer. The assistant began by entering demographic information (gender, age, computer experience) at the keyboard. This information was provided by the nurse.

Figure 1 illustrates two possible states of the computer-generated schematic face as it appears on the hand-held computer. There was only a single face on the screen at any one time. The outline of the head and the nose never changed. By pressing the 'up' and 'down' arrows on the display the child could change the shape of the mouth in successive steps from a state of smiling (up-turned corners) to a neutral state (straight line) to a state of frowning (down-turned corners), while automatically and simultaneously, changing the eyes from completely open (associated with the maximum smile) to half open (neutral) to completely closed (maximum frown). The quantitative procedure for changing the facial expression is described in Appendix A (Fig. 1A). The ratings could be fine-tuned by changing the expression in either direction (positive or negative) multiple times until the child was satisfied.

Study 1—By changing the position of the corner of the mouth in small steps, visually continuous changes in expression were achieved. Each depression of an arrow led to a slight modification in the expression. If the arrow was depressed and not released, the changes occurred quickly and continuously. In this manner, the possible expressions spanned a range from extreme happiness to extreme pain. When children told the assistant they were finished with a rating, the current score, ranging from −10 (maximum frown) to +10 (maximum smile), was automatically recorded and written to a data file. There were 21 steps of facial expressions; this number was segmented into 10 degrees of smiling above "neutral" and 10 degrees of frowning below "neutral." The use of this number of steps was based on previous data[12] showing that such a scale had the same sensitivity to differences in pain as a continuous Visual Analogue Scale.

The background color of the face was "sand," the outline of the face and nose was "blue," and all features were "blue" when the mouth was in the neutral position. For expressions portraying a smile, the mouth and eyes were "green", and for expressions portraying a frown, the mouth and eyes were "red." The colors of these features switched appropriately as the face underwent transformations from one expression to another in order to highlight the difference between smiling and frowning (Fig. 1).

The Wong-Baker Faces Scale consists of six faces ranging from smiling to frowning and oriented in a horizontal series on a sheet of cardboard.[20,21] In the present instance, numerical values (0 through 5) were associated with each face but were not shown to the child.

The procedure consisted of a practice and five test trials on the first occasion, followed for a subset of the patients, with a single trial on a second occasion 15 minutes later. The initial position of the face was always "neutral." The sequence on the first occasion was as follows: (1) the assistant showed the child how the arrows changed the facial expression, and then left the display in the neutral position, (2) the assistant asked the child to "try out" the display by depressing the arrows, (3) the assistant asked the child to indicate what the face would look like when someone was "a little hurt", "hurt a lot", "a little happy", and "very happy". These four test trials were presented in a random order for each participant. (4) The assistant asked the child to "show me how you feel right now." (5) Fifteen minutes later, 61 patients made a second rating of "how you feel right now." In all cases, the second assessment was conducted before any medication or other means was provided to treat a patient's pain. The standard psychometric approach taken with adults of separating test occasions by one or two weeks is a practical impossibility here; first, because acute pain does not always stay constant over even a brief period for this patient population (especially those being treated in the Emergency Department), and second, because many children do not remain in the hospital for more than a few hours.

The ratings were recorded in the same file that contained the demographic information (age, gender, computer experience). The procedure for trials 1 through 4 took approximately 3 minutes; trial 5 (single rating) took less than 30 seconds.

The child also was asked on the first occasion to select a face from the Wong-Baker series that represented how she/he felt now. The standard instructions from the Wong-Baker Faces Scale were used to identify each face in the series to the child. To do this, the assistant pointed to each of the five faces in turn and stated: "The person": a) is very happy because he doesn't hurt at all, b) hurts just a little bit, c) hurts a little more, d) hurts even more, e) hurts a whole lot, and f) hurts worst. The child was then asked to choose a face that showed how he or she felt now. When ratings for both methods were completed, the children were asked which of the two methods (computer or paper) they liked best. The assistant entered a coded value for the preferred method into the computer.

The two assessment methods were counterbalanced so that approximately half the participants received the Computer Face Scale first, followed by the Wong-Baker Faces Scale, and the other half of the participants received the methods in the opposite order.

Study 2—A conceptual issue is raised by the procedure used in Study 1 in that one is not sure whether the child is rating the state of pain, is giving an indication of mood (happy or sad), or is reporting some mix of the two states. Study 2 was undertaken to disengage the measurement of these two concepts by using two versions of the Computer Face Scale: one to measure a child's pain, the other to measure a child's mood. The first version allowed the facial expression to extend from "neutral" to "frowning" when the child was asked to show "how much you hurt now", and the second version allowed the facial expression to vary from frowning to smiling when the child was asked "show how you feel now." This order of the two types of ratings was always the same. We fixed the order because in pilot work we found that it was confusing for the child to see the full range of the facial expression (for mood) and later be asked to indicate pain when the face could then only vary from neutral to frowning. Presenting the two versions in the order (pain first followed by mood) was not confusing. Fifteen minutes later the child was asked again to indicate pain and mood using the same two methods. All other procedural details were the same as those followed in Study 1.

Statistical Analysis

All analyses were conducted with SPSS (version 16) of Chicago, Illinois. Because it seems likely, but not certain, that the Computer Face Scale yields measurements at the interval level, both parametric and non-parametric statistics were computed. Parametric tests are reported here for all tests of significance ($p < 0.05$, two-tailed test), except for the correlation and preference data involving the Wong-Baker Faces Scale. All other comparable non-parametric tests yielded essentially the same results as those found with parametric tests, and hence, will not be reported.

Results

Ninety-six percent of the children reported having some computer experience, and none stated they had any difficulty using the method.

Study 1

All patients satisfied at least one of two conditions: correct rank order (hurts a lot, hurts a little, a little happy, very happy) or correct assignment of smiley face to happiness and frowning face to pain/hurt. A summary of the quantitative ratings is given in Table 1. A one-way ANOVA indicated highly significant differences among the mean ratings for the four statements (hurts a lot, hurts a little, a little happy, very happy).

Of the 79 patients, 39 % of the children indicated that they were in pain or hurt "now" by creating a frowning face, 14 % created a neutral face, and the remaining 47% indicated that they were "happy" by creating a smiling face. A tercile split on age (three approximately equal-sized groups) revealed similar minima, maxima, and standard deviations for the three age groups. The rank order correlation (Spearman's rho) between the ratings on the Computer Face Scale and the ratings on the Wong-Baker Faces Scale was −0.68 (low scores on the first scale indicate greater pain, whereas high numbers on the second indicate greater pain). This value is significant ($n = 79$, $p < 0.001$ two-tailed test). When asked to indicate which of the two methods they liked best, 2 participants were neutral, 61 participants (77 %) preferred the Computer Face Scale and 15 participants (19 %) preferred the Wong-Baker Faces Scale. This difference is significant by the binomial test ($p < 0.001$, two-tailed). The dominance of the CFS over the Wong-Baker was less for the older group of subjects than for the two younger groups.

Most participants (N = 34) who were tested twice indicated they were in pain on the first occasion of the test, 16 participants indicated they were happy, and 11 participants were neutral. The mean rating of “pain now” was −1.3 (sd = 4.8) on the first test occasion, and −0.49 (sd = 5.8) on the second, with similar minimum, maximum, and median values on both occasions.

The intra-class correlation (test-retest reliability, absolute agreement)[15] between the two tests regarding “now” ratings was r = 0.77 (N = 61, p < 0.001). There was no significant difference between the mean ratings on the two occasions separated by 15 minutes, as determined by paired t-test (df = 60, t = 1.7, p = 0.1). These findings indicate that the Computer Face Scale is reliable (high temporal stability) at least over the time interval that was practical to test in the present hospital circumstances.

Study 2

Descriptive statistics are presented in Table 2. There is a statistically significant Pearson product moment correlation between the two types (pain and mood) of ratings (occasion 1, r = 0.44, p < 0.01, two-tailed test; occasion 2, r = 0.46, p <0.01). These findings are in agreement with the results obtained when adults in pain are asked to rate pain on the one hand and emotional impact of pain on the other using a Visual Analogue Scale.[9,17] There was no significant difference (paired t-test) between pain ratings obtained on two occasions, or between mood ratings obtained on two occasions. The test-retest reliability (intra-class correlation) for both forms of ratings (r = 0.80 for pain; r = 0.82 for mood) was slightly higher than the value found in Study 1 when children only rated pain.

The ability of the Computer Face Scale to distinguish between the constructs of pain and mood can also be assessed from the data in Study 2. A common index for discriminant validity is obtained by dividing the correlation between pain and mood ratings (in this case, 0.45) by the square root of the cross product of the reliability coefficient for pain and the reliability coefficient for mood [sqr(0.80 × 0.82)].[11] A numerical value less than 0.85 indicates discriminant validity. The calculated value from our data is 0.45/0.81 = 0.55. Thus, the Computer Face Scale shows discriminant validity in respect to the measurement of pediatric pain and mood.

Discussion

In Study 1, we demonstrated that children are able to express their pain by adjusting the facial expression of a cartoon figure displayed on a hand-held computer. The results obtained replicate the findings from our previous study with a laptop computer[4] by establishing the *concurrent validity* and *test-retest reliability* of the CFS, and by showing that the majority of children prefer using the CFS over the poster format of the Wong-Baker Faces Scale. Both assessment methods give the child the option of selecting a smiling face, so the preference for the computer method may not depend on the content of the displays, but only on the fact that children enjoy using computers. Our study was not designed to determine the underlying reasons for this preference. We would argue, however, that from the clinical standpoint of a health provider attempting to secure symptom ratings from their patients, it is important to use a method that children find enjoyable.

Several investigators have emphasized the necessity to separate a child’s rating of pain from the affective mood state accompanying pain, or from the degree to which the pain is “bothersome.”[6,7,13,14] Study 2 was conducted to address the possibility that children in Study 1 using the full range of the CFS (smiling to frowning) or the Wong-Baker scale are inconsistent regarding the target symptom whose intensity is being reported. A child in Study 1 may have interpreted the investigator’s instructions of “how I feel now” in two different ways: how much pain is being experienced or how much my mood is affected by hospitalization. The reason this distinction is important is that the response of the caregiver will depend on whether the child indicates he/she is suffering from pain, or is unhappy for this or other reasons (e.g., being immobilized, the parents or therapy dog just left the room, lack of visitors, the hospital menu is unappetizing, and so forth). A child in pain may require medication; whereas, a child who is unhappy for other reasons may require psychological or social counseling. The patient who is both in pain and unhappy may be treated with an increase in medication as well as counseling; whereas, no action may be necessary for a patient who is neither in pain nor unhappy.

In Study 2, we demonstrated that children are able to separate the meaning of instructions regarding the symptoms of pain and mood, although the two ratings were moderately correlated. The test-retest reliability of both pain and mood ratings was also established for both symptoms, though the test-retest interval was only 15 minutes. In future work it would be desirable to test pediatric patients diagnosed with chronic pain, instead of acute pain, and to employ a longer time interval between test occasions (one or two weeks).

The results of both studies, as well as our previous work,[4] show that most children realize that greater amounts of frowning are associated with greater amounts of pain and that greater amounts of smiling are associated with greater amounts of happiness. This outcome suggests that the CFS can be considered at least an ordinal scale, but it is not clear whether or not the scale also satisfies the requirements of an interval scale.[2,19] For clinical purposes, an ordinal scale of measurement may be sufficient if all one is after is an indication that a child's pain or mood has increased or decreased relative to an earlier measurement. Our demonstration in Study 1, however, that the child understands the link between relative degrees of pain and appropriate changes in facial expression means that it is not necessary to include such pre-trials in clinical applications, unless one has independent evidence that the child does not fully understand what is being requested.

This work is also in concert with the current upswing of computer applications in clinical settings.[10] In their article on electronic subject diaries in clinical trials, Raymond and Ross[18] list the advantages for electronic data acquisition as compared to paper-and-pencil administrations, such as those typically used for face scales. These advantages include a) direct transfer from a user's computer device to a central database, b) no necessity for staff to enter data, actively manage the database, or clean the data, and c) ability of a dynamic display to permit a variety of user-friendly and visually meaningful data entry elements and formats. In addition, once a patient's data are entered into an electronic database it is possible to track changes in symptoms over time in response to treatment.[16] In light of these technological developments, there is clinical promise for a computer system that collects, analyzes, and displays assessment data from children. More specifically, the present research supports and extends previous studies that employed a computer system for measuring pediatric pain by the use of face scales.[3,4]

The next projected step in this research program is to examine the method's sensitivity in tracking pain and mood ratings by children who are recovering from a medical procedure whose impact is expected to change over time. If successful, such studies would further bolster the construct validity of the method.

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Appendix A

The approach for generating facial expressions is based on a provisional U.S. patent.[1] Figure A.1 illustrates the method. An *x*-*y* coordinate system is imposed with its origin at the center of the mouth (*x*-axis). A positive quadratic equation generates different degrees of smiling and a negative quadratic equation generates different degrees of frowning. By changing the magnitude of the scalar multiplier (λ) in the equation by small steps, essentially continuous changes in expression can be produced, though larger successive changes are possible by using larger step sizes. The value of λ is under software control (the ‘up’ and ‘down’ arrows shown in Fig. 1). In this manner the range of recorded values is from λ to −λ, representing an entire spectrum of emotions from extremely positive (or happiness) to extremely negative (or sadness/ pain). The maximum smile and the maximum frown are depicted in Fig. A.1 and illustrate the extremes of facial expressions that can be generated. At each point in time during the adjustment process, the value of λ (including its sign) indicates the rating of positive or negative feelings, and can be further scaled, if desired, (e.g., from −10 to +10) and written to a data file for later analysis.

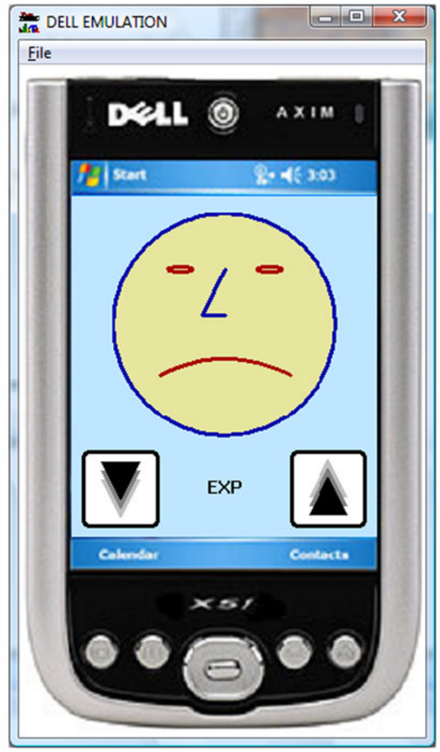

Figure 1.
Sample facial impressions produced by the Computer Face Scale as implemented on a hand-held computer. Animated changes are produced by depressing the 'up' (smile) and 'down' (frown) arrows on the screen using a stylus, fingers or thumbs

Figure A.1. Illustration of the computational method used to generate degrees of smiling and frowning by the Computer Face Scale.

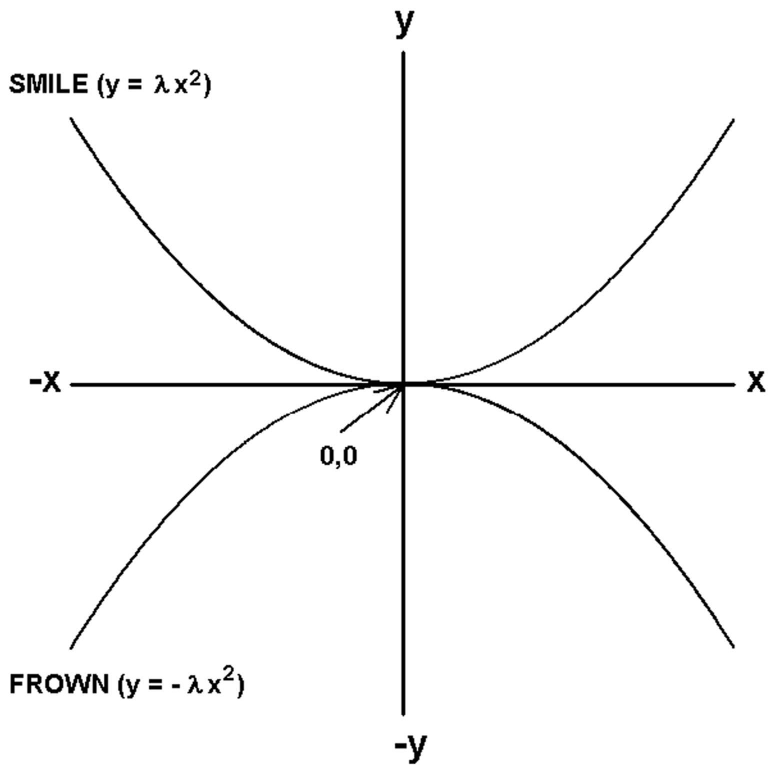

Figure A.1.
Illustration of the computational method used to generate degrees of smiling and frowning by the Computer Face Scale.

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Table 1

Ratings of pain# by 79 hospitalized children in Study 1

	Very Happy	Little Happy	Hurts a Little	Hurts a Lot	Feel Now	Wong-Baker##
Median	9	3	−2	−7	0	3
Minimum	−2	−2	−10	−10	−10	0
Maximum	10	10	4	1	10	10
Mean	8.2	3.0	−1.8	−6.9	0.7	3.3
St. Dev.*	2.5.	2.2	2.3	2.9	4.5	2.7

*Standard deviation

#extreme happiness (+10) to extreme pain (−10)

##range of very happy (0) to hurts worst (5)

Table 2

Ratings of pain and mood by 50 hospitalized children in Study 2

	Occasion 1		Occasion 2	
	Pain#	**Mood**##	**Pain**#	**Mood**##
Median	−1	4	−0.5	4
Minimum	−8	−8	−10	−5
Maximum	0	10	0	10
Mean	−1.6*	3.4**	−1.6*	3.6**
Standard Dev.	2.0	2.1	5.1	4.8

#(0 = no pain, 10 = maximum pain)

##(−10 = feeling worst, 10 = feeling best)

*t = 0, p = 1

**t = 0.46, p = 0.64