The Computer-Assisted Cognitive/Imagery System for use in the management of pain

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BACKGROUND: There is growing interest in computer-delivered psychological interventions for a number of clinical conditions, including pain.

OBJECTIVES: This study tests the effectiveness of a new computer-delivered pain-management program using a laboratory pain paradigm.

METHODS: One hundred twenty undergraduate students were randomly assigned to either the computerized pain-management group or the distraction control group. Subjects underwent a cold-pressor task and were asked to continuously rate their subjective pain experience.

RESULTS: Women receiving the computerized pain management intervention were able to tolerate the cold-pressor task longer than those in the control group. No effect was found for men. Subjective pain ratings were consistently lower during the cold-pressor task for subjects in the computerized pain-management group regardless of sex. Subjects receiving the computerized intervention reported feeling more comfortable and relaxed than control subjects during the cold-pressor task.

CONCLUSIONS: Findings indicate that further investigations of the program used in this study are warranted to determine its potential clinical utility and that of similar computerized interventions for pain.

Key Words: Cognitive; Computer; Hypnosis; Imagery; Pain

While many early computer psychotherapy modules were largely didactic in nature and focused on psychoeducation interventions, several programs have been developed to be more interactive (8,14). The use of the internet has furthered this aim by providing psychotherapy modules that sometimes involve real human interactions carried out in cyberspace (15-18). Another new technology that has been widely applied with regard to psychological services is virtual reality (VR). VR involves immersing patients in an interactive computerized three-dimensional world that can be modified to contain specific elements that may be relevant to certain psychological/behavioural problems and/or clinical goals. VR has been used to deliver exposure-based therapies for various phobias, including fear of heights, flying, claustrophobia, driving and spiders (5).

There has been considerable research conducted on the use of VR in the management of pain (19-21). This is an important line of research because chronic pain conditions are poorly...
understood, poorly treated, and are a significant public health concern costing billions of dollars each year in lost wages, lost productivity and disability expenses (22). Additionally, acute pain conditions can be problematic to manage and risky because use of anesthesia (general and local) during some medical procedures can sometimes be contraindicated and often does not provide adequate pain relief. There is a growing body of evidence that VR can be used to significantly reduce pain in laboratory paradigms and the clinic (eg, burn débridement, dental procedures). VR is generally believed to work for the treatment of pain by distracting subjects from the noxious stimuli responsible for the pain (18,19).

Several psychological interventions and procedures have been shown to be effective in the management of acute and chronic pain conditions. Specifically, cognitive-behavioural therapy, group therapy, relaxation training and psycho-educational interventions have been shown to reduce pain intensity and increase functioning in chronic pain sufferers (23,24). There is also extensive empirical support for the use of hypnosis in the management of chronic and acute pain conditions (25-27). These effects appear to exceed placebo and/or relaxation effects and seem to be dependent on the patient’s natural abilities to respond to hypnotic suggestions for analgesia, dissociation or distraction rather than the hypnotist’s authority, demeanor, voice or wording of suggestions.

Grant and Nash (28) introduced a computer-delivered hypnotic assessment program that was shown to have acceptable reliability and validity. The program administered a hypnotic induction and then assessed responsiveness to suggestion using behavioural items that were scored either by the subject or the computer depending on the item. This project demonstrated that the computer is a feasible medium for delivering hypnotic procedures.

While computers have been used to manage various clinical pain conditions and administer hypnotic procedures, there have not been many computer programs developed to deliver hypnotically-based interventions for pain. This is unfortunate given the strong empirical evidence demonstrating its clinical efficacy for acute and chronic pain conditions.

The present study seeks to test the effectiveness of a computer-administered pain management program using normal college student subjects in a laboratory pain paradigm. The program was based on widely accepted hypnotic and cognitive procedures for pain management to help subjects better tolerate experimental pain. It was hypothesized that subjects receiving the computer-delivered pain management program would be able to tolerate a cold-pressor pain task longer than subjects who were asked to listen to a story (serving as a mild distraction control condition). Additionally, subjective pain ratings were hypothesized to be lower in the pain program group than in the control group. Lastly, it was hypothesized that subjects receiving the pain program would report that they felt more comfortable and relaxed during the cold-pressor task than control subjects.

METHODS

Subjects
One hundred twenty undergraduate students enrolled in psychology courses at the University of Tennessee were given extra credit for participation in this study. There were 52 men and 68 women with a mean age of 20.41. There were 26 men and 38 women in the control group, and 26 men and 30 women in the experimental group ($\chi^2$[degrees of freedom=1, n=120]=0.41, not significant). The mean age of subjects in the control group was 20.29 (SD=2.38) and the mean age of subjects in the experimental group was 20.52 (SD=2.86). No age-differences were found for sex, group-assignment, or the sex by group interaction (F[3,116]=0.84, not significant). It appears that the randomization procedure did not result in any systematic bias with respect to the age and sex of subjects assigned to each group.

Computer-Assisted Cognitive/Imagery System
The Computer-Assisted Cognitive/Imagery System (CACIS) was developed using an object-oriented visual basic environment for Mac Os (RealBasic 4.02) (Apple Computer Inc, USA) and cross-compiled for Windows95/98/NT (Microsoft Corporation, USA) by the first author. It was administered using the Windows98 platform on a Dell Computer (Dell Inc, USA) (300 MH: Processor and 64 MB of RAM).

On starting the program, users are prompted for their age and sex. The main program interface depicts a blank human figure on a black screen. The sex of the figure automatically adjusts to match the indicated sex of the subject. The portion of the human figure that corresponds with the location of the subject’s pain is highlighted with colour. For the present study, the left hand and forearm of the figure was coloured blue to correspond with the location of sensations experienced during the cold-pressor task.

There is a digital visual pain meter to the right of the figure that is controlled with the ‘arrow’ keys on the keyboard. The scale ranges from one to 20, although the numbers are not visible on the screen. The scale has three text anchors: “no discomfort at all,” “moderate discomfort” and “unbearable, intolerable pain.” Figure 1 shows a screenshot of the main interface.
The program begins by playing a 4 min recording of a male voice providing a brief hypnotic induction comprised of verbal instructions to relax, breathe freely and deeply, and focus attention on the computer screen. Suggestions are also given to attend to bodily sensations (eg, the feeling of the chair against the subject's body) as a means of demonstrating to the subject that they can choose which sensations to attend to at any given time. Efforts are made to cognitively frame the pain experience for the subject so that it is ‘uncomfortable’ rather than ‘painful’ and in such a way that emphasis is placed on the notion that the subject’s experience is under his/her control. During this introduction, the green frame around the human figure appears to slowly rotate around the figure to be more visually captivating.

The CACIS program has three modules that were all implemented in the same order for the present study. Throughout all the modules, the pain meter was controlled by subjects using the arrow keys. The level of the meter was silently recorded by the program every 2 s and the values were saved to an SPSS database (SPSS Inc, USA).

Module 1 involves suggestions to imagine the sensations of cold-pressor pain as the colour blue, corresponding with the human figure on the screen. Suggestions are then given to imagine that the colour is slowly changing to a ‘warmer’ colour. As these suggestions are given, the program animates the human figure such that the blue colour (representing cold-pressor pain) in the left forearm slowly changes to red.

Module 2 involves suggestions for imagining the sensations of pain ‘fading away’ and ‘disintegrating.’ While these suggestions are being given, the image of the pain sensation on the screen (now red) slowly disintegrates and fades to white.

Module 3 involves suggestions for any residual pain sensations to ‘leave the body’ and drift away. While these suggestions are given, the image on the screen animates such that the residual red dots representing pain in the figures arm float out of the arm and off the screen.

Figure 2 shows progressive screen shots of images from each of the three modules.

Control-group program
The control-group program is identical to the CACIS program in terms of computer screen layout and operation of the digital pain meter. However, instead of the script used in the CACIS program, the computer plays a recording of the same male voice reading a story about bird migratory patterns (matched for length). Additionally, the control program presents the human figure with the blue colouring on the left forearm; however, no animation is used and no suggestions are given for altered experiences or visual imagery. The subject is simply instructed to relax and listen carefully to a short story.

Cold-pressor task
A 75.71 L insulated plastic rectangular tank was filled with ice water and an electric pump was attached inside the container to constantly circulate the water. A digital thermometer was mounted inside the tank and water temperature was monitored and maintained at 0.56°C by adding ice when necessary.

Subjects submerged their left hand and arm in the ice bath up to the elbow. They were instructed to remove their arm from the ice bath when they could not tolerate the discomfort any longer. Subjects were not allowed to keep their arms in the ice bath for longer than 150 s. Subjects were given a warm, dry towel after removing their arms from the ice bath.

Follow-up questions
After completing the task, subjects were prompted by the computer to indicate how comfortable they felt during the cold-pressor task and how relaxed they felt during the cold-pressor task using a 5-point Likert scale (1=not at all, 5=completely).

Procedure
Subjects were brought individually to a sound-proof laboratory room in the psychology building at the University of Tennessee. They read and signed the informed consent form and were given an opportunity to ask questions about the cold-pressor task. Subjects were told that they would be doing the cold-pressor task while interacting with a computer but subjects were not made aware of the aims, design or hypotheses of the study. Subjects sat at the computer and completed a 1 min practice trial using the digital pain meter to get familiar with the scale and the controls with the help of a lab assistant. Subjects then started the program and the research assistant moved out of the subject’s line of sight. Once started, the program...
However, there were twice as many men (n=22) as women in the CACIS group who reached the ceiling (16 and 17, respectively). Approximately equal number of subjects in the control and CACIS groups were unable to tolerate the cold-pressor pain for the entire 150 s (ceiling effect). There was an interaction between group and sex regarding the length of time subjects were able to tolerate the cold-pressor pain, as long as women in the CACIS group or as long as men. Main effect for sex (F[1,116]=13.40, P<0.0001) and a significant difference between groups. There were no significant differences between groups or sex for the first 60 s of the cold-pressor task.

DISCUSSION
Subjective pain ratings
Subjective pain ratings (collected silently by the computer program every 2 s) were examined throughout the first 60 s of the cold-pressor task. Since subjects were to remove their arms from the ice bath when they were unable to tolerate the discomfort any longer (and therefore no longer gave pain ratings), the number of subjects contributing to the mean pain rating at any given time-point varied. Specifically, there were fewer and fewer subjects available to give pain ratings across time during the cold-pressor task. By 60 s into the task, half of the subjects had discontinued and thus mean estimates became much less reliable during later portions of the task. Figure 5 shows the mean subjective pain ratings over time between the control and CACIS groups for the first 60 s of the cold-pressor task. Ratings from subjects in the CACIS group were consistently lower than ratings from subjects in the control group. Figure 6 shows the mean subjective pain ratings over time between men and women. Men consistently gave lower pain ratings than women throughout the first 60 s of the cold-pressor task.

Follow-up questions
Subjects in the CACIS group indicated that they were significantly more comfortable during the cold-pressor task than control subjects (t[110]=3.26, P=0.001). Additionally, CACIS subjects reported being more relaxed during the cold-pressor task (t[110]=2.27, P=0.025). Figure 7 shows the mean ratings for each group on each of the self-report questions.

RESULTS
Cold-pressor tolerance
Subjects in the control group were able to tolerate the cold-pressor task for a mean of 73.25 s, whereas subjects receiving the CACIS program tolerated the cold-pressor for a mean of 86.25 s (t[118]=1.40, P=0.16). While this failed to reach statistical significance, a 2x2 ANOVA with group (control versus CACIS) and sex (male versus female) indicated a significant main effect for sex (F[1,116]=13.40, P<0.0001) and a significant interaction between group and sex regarding the length of time subjects were able to tolerate the cold-pressor pain (F[1,116]=6.55, P=0.012). Figure 3 displays the means for men and women in the control and CACIS groups. Women in the control condition were unable to tolerate the cold-pressor pain as long as women in the CACIS group or as long as men.

Thirty-three subjects (27.5%) kept their arms in the cold-pressor for the entire 150 s (ceiling effect). There was an approximately equal number of subjects in the control and CACIS group who reached the ceiling (16 and 17, respectively). However, there were twice as many men (n=22) as women (n=11) that reached the ceiling. Figure 4 shows the mean time that male and female control and CACIS subjects tolerated the cold-pressor after subjects who reached the ceiling were removed from the analyses. It appears that women in the control group had lower pain tolerances than men in the control group. While the CACIS program did not appear to provide any significant benefit to the men in our sample, the CACIS program increased the women’s pain tolerance to match that of the men in our sample.

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DISCUSSION
Pain, once thought as an inevitable consequence of certain medical procedures and chronic conditions, is a phenomenon...
receiving greater amounts of attention from the scientific and medical communities. Furthermore, the rising incidence rates of chronic pain conditions such as rheumatoid arthritis, fibromyalgia and irritable bowel syndrome have increased the need for effective techniques for controlling pain.

The present study demonstrates that hypnotic/imagery techniques can be combined with computer-based protocols to induce acute pain. The use of the computerized hypnosis/imagery program was superior to the mild distraction program in lowering experienced pain. Both men and women indicated that they were significantly more comfortable and relaxed when using the CACIS program as opposed to distraction during the cold-pressor task. These post-task measures were further supported by pain data collected during the task, which showed the CACIS group experiencing significantly less pain than the control group. Lastly, the effectiveness of the CACIS technique was validated by behavioural responses (eg, the amount of time subjects' hands stayed in the water), although this effect was found for women only. Because men showed no significant difference in the time they withstood the task despite reporting elevated pain in the control condition, we infer that other factors (besides degree of experienced pain) determined how long men chose to endure the painful laboratory stimulus, or that the maximum period of arm exposure was not sufficient enough to reveal individual differences in pain tolerance among men (eg, ceiling effect).

Our laboratory findings document that computer-based hypnotic-cognitive interventions can be effective helping subjects manage experimental pain. This is promising. However, serious questions remain, not the least of which is whether the benefit of this computer-based intervention will generalize from the laboratory to the clinic. Will this intervention be helpful to patients suffering from chronic pain? Will it help patients better tolerate acute instructive pain of some medical procedures? Will it do either of these things as well as, or better, than proven distraction techniques presently used in clinics?

Furthermore, little attempt was made in the present study to identify the many factors that might make an individual more or less responsive to the CACIS technique. The only individual variable measured was sex, which did interact with the effectiveness of the program. These results support previous findings showing that men and women react differently to pain-intervention techniques (29) and lend further credence to calls for sex-specific pain management strategies (30).
CONCLUSIONS

Based on the information provided by this study, we do not know what specific aspects of the CACIS program were associated with significant benefit (eg, audio, suggestions, visual stimulation/distraction, animation, relaxation effects, etc.). Future studies should investigate which aspects of the CACIS program provide the most benefit by systematically removing and/or adding different components of the program and testing the modified program against other versions. Fortunately, because of the nature of computer-delivered interventions, modifications such as these can be implemented quite easily.

Personality and cognitive variables may also determine to what extent an individual reacts to any one pain-management technique. Several distinct pain-response styles have been identified (31) and pain control has been found to be more effective when coping styles and pain management strategies are congruent (32). With regard to the present study, sensitizers may be more responsive to the CACIS protocol while responders would find distraction techniques to be more helpful. Cognitive factors (such as imagery ability) may further shape the effectiveness of pain management interventions. One of the greatest benefits of computerized pain-control programs is their flexibility. As future studies determine the factors that best predict efficacious pain-management strategies, computers may be able to both assess and deliver the most appropriate program for each individual. These programs may free up time for medical professionals and the portability of newer devices may make ambulatory pain-management protocols a feasible option for pain or postoperative patients. The results of the present study provide continuing support for the use of computers in pain intervention.

REFERENCES


