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Investigating patient characteristics on pain assessment using virtual human technology

Lauren A. Stutts, M.S.,
University of Florida, 750 Bergen Rd Apt 604, North Augusta, SC 29860, 704.582.9343 (phone)

Adam T. Hirsh, Ph.D.,
University of Washington

Steven Z. George, Ph.D., and
University of Florida

Michael E. Robinson, Ph.D.
University of Florida

Lauren A. Stutts: lstutts@phhp.ufl.edu

Abstract

Pain assessment and treatment is challenging and can be influenced by patient demographic characteristics. Few research studies have been able to specifically examine these influences experimentally. The present study investigated the effects of patients' sex, race, age, and pain expression on healthcare students' assessment of pain and pain-related sequelae using virtual human (VH) technology. A lens model design was employed, which is an analogue method for capturing how individuals use environmental information to make judgments. In this study, decision-making policies were captured at the nomothetic and idiographic level. Participants included 107 healthcare students who viewed 32 VH patients that differed in sex, race, age, and pain expression in an online study. Participants provided ratings on a 100-point scale on the VH pain intensity, pain unpleasantness, negative mood, coping, and need for medical treatment. Nomothetic analyses revealed that female, African American, older, and high pain expression VH were rated higher than male, Caucasian, younger, and low pain expression VH, respectively, on most of the five ratings. Idiographic analyses revealed detailed findings for individuals' decision-making policies. VH technology and the lens model design were shown to be highly effective in examining individuals' decision making policies. Pain assessment often varied among individuals based on patient demographic and facial expression cues. This study could serve as a model for future investigations of pain assessment and treatment in healthcare students and providers.

Keywords

assessment; psychology; virtual technology; healthcare students

Correspondence to: Lauren A. Stutts, lstutts@phhp.ufl.edu.

Introduction

Pain assessment is challenging because of the subjective component of pain (Dworkin and Sherman, 2001). Although there are a myriad of potential influences on pain assessment, the following patient characteristics have been previously identified as important considerations in this context and are the foci of the current study: sex, race, age, and facial pain expression.

Women and men have been shown to experience differential responses to pain (Robinson et al., 2004). Clinically, women report more pain sites and increased healthcare utilization relative to men (Fillingim et al., 1999). Experimentally, women have been found to have significantly lower thermal threshold detection, pain threshold, and pain tolerance than men (Fillingim et al., 1999).

Race/ethnic differences in the pain experience are also important factors. Clinically, compared to other race/ethnic groups, African Americans report higher levels of pain in conditions such as AIDS (Breitbart et al., 1996), glaucoma (Sherwood et al., 1998), migraine headaches (Stewart et al., 1996), and post-surgery (White et al., 1999). Experimentally, African Americans and Hispanics have been shown to demonstrate lower pain tolerance and higher pain unpleasantness across pain stimuli than Caucasians (Campbell et al., 2005).

Age is another critical demographic factor to explore. Although pain is common in the elderly population (Ferrell et al., 1990; Helme and Gibson, 2001), it is under-recognized in older adults compared to younger adults (Horgas and Elliott, 2004). One contributor to this problem is that healthcare settings typically do not routinely assess for pain in elderly patients (Chodosh et al., 2004). Difficulties in pain assessment are also compounded by other medical problems and cognitive impairments in older adults (Charlton, 2005; Gagliese, 2001).

Patients typically express pain through verbal reports and nonverbal behaviors (Keefe et al., 2001). Facial pain expression is a particularly salient way for individuals to communicate their pain experience (Schiavenato et al., 2007). The validity of a universal facial pain expression has been supported by the consistency of facial pain expression across cultures, the early development of facial expression in infants, and the ability for congenitally blind infants to develop facial expression without visual cues (Craig et al., 1994; Fridlund, 1994).

Two recent studies investigated clinical decision making for pain assessment and treatment using novel virtual human (VH) technology in nurses and undergraduate students (Hirsh et al., 2008; Hirsh et al., 2009). With this technology, the features of an empirically-validated pain expression can be altered to represent varying degrees of pain expressivity. Different levels of pain expression can be held constant and applied to a range of characters. Virtual technology allows for a level of experimental control that is lacking in retrospective-based research and permits a level of ecological validity that is lacking in purely vignette-based research.

The present study aims to examine examining the pain assessment and treatment decisions of healthcare students, a population yet to be explored. This is an important avenue of research since students will be making important pain-related decisions in the near future. This research could also potentially lead to improved education for pain treatment.

Methods

Participants

Participants included 107 healthcare students from the University of Florida. Approximately 77.6% of the participants were female, 69.2% of the participants were self-reported Caucasian, and 82.2% of the participants were single (Table 1). The average age of the sample was 24.62

years (*SD* = 4.17) with a range from 19 to 48. The sample was comprised of 34 physical therapy students, 30 nursing students, 25 medical students, and 18 dental students. Table 2 presents the number of students per training year. Local recruitment strategies included announcements via email to students and advertisements displayed in the college departments. Approximately 800 students were contacted and 13% participated. All participants provided informed consent and were compensated $15 for their participation.

Procedure

The Institutional Review Board (IRB) at the University of Florida approved the following study procedures. This study employed a lens model design. This design is an analogue method for capturing how individuals use environmental information to make judgments (Cooksey, 1996). It serves as a theoretical model and an experimental paradigm for studying judgment processes and outcomes (Beal et al., 1978). Empirical applications of this approach typically consist of a series of cue-containing profiles presented to a study participant, about which the participant forms a judgment (Hammond, 1996). This judgment is recorded via a quantifiable response mode like a visual analog scale.

An online delivery model was used for the present study. Participants provided electronic consent if they agreed to participate. Subsequently, participants completed the demographics questionnaire and then observed 32 patient profiles. For each patient profile, participants read a clinical vignette about a patient who has chronic lower back pain (Appendix A) and viewed a VH video simultaneously. The video consisted of a 20-second looped clip of a VH patient. The VH used in this study were created by *People Putty* and were used in two previous studies (Hirsh et al., 2008; Hirsh et al., 2009). Each VH contained four cues: sex (male, female), race (Caucasian, African-American), age (young adult, older adult), and pain expression (low, high). The cues of sex, race, and age were demonstrated by altering the appearance of the face. An empirically-validated pain expression was created based on facial action units from the Facial Action Coding System (FACS) (Ekman and Frieson, 1978). A total of 16 unique scenarios were created to represent all possible cue combinations. Two examples of the virtual humans are presented in Appendix B. In order to maximize study power and achieve optimal task sensitivity, each possible cue combination was presented twice to each participant, resulting in a total of 32 patient profiles. To control for order effects, patient profiles were presented randomly.

Five assessment ratings were obtained for each profile presented. Participants rated each VH level of pain intensity, pain unpleasantness, negative mood, pain coping, and need for medical help. Pain assessment ratings were recorded on separate 100-point visual analog scales. Endpoints ranged from *no pain sensation* to *most pain sensation imaginable, not at all unpleasant* to most *unpleasant imaginable, no negative mood at all* to *most negative mood imaginable, best adaptive coping* to *worst coping*, and *not at all likely* to *complete certainty*.

Finally, a short questionnaire was included to assess for participants' background in pain assessment. This questionnaire was developed for this study and was used descriptively. For each item, participants used the 100-point visual analogue scale that was used in the patient profile section of this study with end markers relating to the question. Participants were asked to rate their amount of training in pain assessment, their amount of familiarity with different pain conditions, their amount of competency in pain assessment, and report whether they had worked with a patient with chronic back pain previously.

Statistical Analyses

Descriptive statistics were conducted to summarize the demographic and background characteristics of the sample. For the nomothetic analyses, descriptive statistics were used to calculate the average rating (across the entire sample) for each cue at each dependent variable. Subsequently, paired-samples t-tests compared those ratings within cue. For the idiographic analyses, simultaneous multiple regression equations were generated for each individual to capture his/her decision making policies. VH sex, race, age, and pain expression served as independent variables in each model. Ratings of pain intensity, pain unpleasantness, negative mood, pain coping, and need for medical help were dependent variables in their respective models. The standardized regression coefficients in each equation represented the weight of each cue in the formation of the assessment judgments. This weight represented the unique contribution and relative importance of each cue in the participant's clinical decision. The coefficient of multiple determination (R^2) represented the amount of variance in assessment decision policies accounted for by the predictor variables, or the overall function of the cues in each individual's policy. Only significant regression coefficients were used in the analyses. Correlations were computed between the ratings of the pairs of videos that the participants' viewed twice to assess for consistency in ratings.

Results

Nomothetic Analyses

Participants assessed female VH to be experiencing higher pain intensity, higher pain unpleasantness, higher negative mood, worse coping, and a higher need for medical help than male VH [$t(106)$ = ranged from 6.33 to 9.6, $p < .01$, Cohen's d ranged from .13 to .33]. Table 3 presents the means and standard deviations.

Participants judged African American VH to be experiencing higher pain intensity, higher pain unpleasantness, higher negative mood, and a higher need for medical than Caucasian VH [$t(106)$ = ranged from 3.10 to 5.46, $p < .01$, Cohen's d ranged from .08 to .19]. There was not a significant difference between ratings for African American and Caucasian VH for pain coping.

Participants assessed older VH to be experiencing higher pain intensity, higher pain unpleasantness, higher negative mood, worse coping, and a higher need for medical help than younger VH [$t(106)$ = ranged from 5.35 to 6.43, $p < .01$, Cohen's d ranged from .21 to .27].

Finally, VH with high pain expressivity were judged to be experiencing higher pain intensity, higher pain unpleasantness, higher negative mood, worse coping, and a higher need for medical help than those with low pain expressivity [$t(106)$ = ranged from 14.39 to 20.20, $p < .01$, Cohen's d ranged from .88 to 1.61].

Idiographic Results

Table 4 shows the number of participants who had significant policies at the individual cue level for each decision domain. Overall, results indicated that 78 to 95 participants out of 107 participants had at least one significant policy, depending on the dependent variable. For the sex cue, 6 to 13 participants had significant policies such that they rated female VH as having higher pain and/or pain-related sequelae than male VH. Conversely, one participant rated that male VH had significantly higher pain intensity levels than female VH. For the race cue, 2 to 7 participants rated African American VH as having higher pain and/or pain-related sequelae than Caucasian VH, whereas 1 to 3 participants rated the opposite. For the age cue, 15 to 17 participants rated older VH as having higher pain and/or pain-related sequelae than younger VH. In contrast, 1 to 2 participants rated that young VH had higher pain or pain-related sequelae than old VH. Finally, 76 to 95 participants rated VH with high pain expressivity as having higher pain and/or pain-related sequelae than VH with low pain expressivity. No participants rated VH with low pain expressivity as higher than VH with high pain expressivity.

Significance in Contextual Cues

Results indicated that sex, race, age, and facial expression cues accounted for as much as 12%, 22%, 37%, and 90%, respectively, of the variance in policies for pain intensity; 16%, 23%, 37%, and 88% for pain unpleasantness; 23%, 20%, 46%, and 85% for negative mood; 14%, 16%, 34%, and 79% for coping; and 18%, 21%, 45%, and 79% for facial expression (Table 5). The overall amount of variance accounted for each policy is also presented.

Correlations Between Repeated Stimuli

All of the correlations between the 16 pairs of ratings for the same video were significant ($p < .01$). For pain intensity, the correlations ranged from .53 to .74. For pain unpleasantness, the correlations ranged from .51 to .66. For negative mood, the correlations ranged from .48 to .66. For coping, the correlations ranged from .43 to .68. Finally, for recommendations, the correlations ranged from .57 to .83.

Training Questions

On a scale from 0 (*no training*) to 100 (*most training imaginable*), the average amount of training participants reported receiving in how to assess pain was 44.35 (*SD* = 26.87). On a scale from 0 (*not familiar at all*) to 100 (*most familiar imaginable*), the average of amount of familiarity participants reported with different pain conditions was 42.50 (*SD* = 23.51). On a scale from 0 (*not competent at all*) to 100 (*most competent imaginable*), the average amount of competency participants reported in assessing an individual's pain was 47.13 (*SD* = 23.00). Approximately 80% of participants reported having worked with a patient with chronic back pain.

Discussion

The current study investigated the influence of patients' sex, race, age, and pain expression on healthcare students' pain-related decision making using an innovative research design and novel VH technology. Investigations of biases in the assessment and treatment of pain have become important in recent years as the healthcare field has aimed to identify and eliminate healthcare disparities (Paulson and Dekker, 2005). While undergraduate students' and nurses' biases have been investigated in two recent studies(Hirsh et al., 2008; Hirsh et al., 2009), there is a gap of research looking at students training to become healthcare professionals. The present study addressed this gap by exploring the biases of graduate students in physical therapy, medical, dental, and nursing programs.

Overall, results of nomothetic analyses were consistent with the literature and previous studies (Fillingim et al., 1999; Hirsh et al., 2008; Hirsh et al., 2009). Specifically, relative to male VH, female VH were rated as having higher pain intensity, higher pain unpleasantness, higher negative mood, worse coping, and more in need of medical help. Even if women experience more pain, on average, than men, there is likely more within-sex variation in pain than between-sex variation in pain (Charlton, 2005). As such, it is not necessarily appropriate to be predisposed to view females as experiencing more pain than males.

African American VH were rated to have higher pain intensity, higher pain unpleasantness, higher negative mood, and were recommended to seek medical help significantly more than Caucasians. Healthcare students may be predisposed to judge African Americans as having higher pain levels due to awareness of the fact that, compared to Caucasians, African Americans have higher rates of clinical pain and disability (Edwards et al., 2001). It was interesting that the current study did not find a difference between ratings of African American and Caucasian VH on coping. It could be more difficult to extrapolate a virtual patient's level of coping based on the data presented than the other dependent variables. Our previous study with undergraduate students did not find any racial biases at the nomothetic level (Hirsh et al., 2008), but the study with nurses did find the same racial biases as the present study (Hirsh et al., 2009). Although additional research is needed, it appears that race functions variably as a bias in decision making about pain.

Older VH were rated to have higher pain intensity, higher pain unpleasantness, higher negative mood, worse coping, and were recommended to seek medical help significantly more than younger VH. Our previous study with undergraduates only found this age bias in coping and medical recommendations (Hirsh et al., 2008), but the study with nurses found the same age biases as the current study (Hirsh et al., 2009). Other studies have found that older adults underreport their pain level, and that pain in this population is under-recognized by healthcare providers (Horgas and Elliott, 2004; Oberle et al., 1990). Since the current study consisted of only facial expressions of pain and did not include patient report, healthcare students may have recognized and assessed patient pain at a higher level. It is also possible that older adults are viewed to have more pain than younger adults because of assumptions made about older adults. For example, individuals may assume older adults have comorbid medical conditions and suffer more than younger adults. These reasons are speculative and would need to be explored further in future investigations.

VH with high pain expressivity were judged to have higher pain intensity, higher pain unpleasantness, higher negative mood, worse coping, and were recommended to seek medical help significantly more than VH with low pain expressivity. The largest percent of the variance was accounted for by pain facial expression, indicating that healthcare students are largely assessing patients using pain cues. The technology should allow future investigations to determine whether the pain cue was simply more obvious, hence used more, or if pain was used independent of stimulus qualities. Both of our previous studies with undergraduates and nurses found similar results, further highlighting the importance of facial expression in ascertaining a patient's pain level and associated factors (Hirsh et al., 2008; Hirsh et al., 2009). This study, thus, provides further validation of the use of an empirically-validated facial expression guided by the FACS to present a pain facial expression.

Idiographic analyses allowed us to examine the influence of specific cues on individuals' pain decision policies. For this discussion, we use the term “bias” to reflect the use of a cue. We found that participants were not consistently biased in one direction for race and age cues. For example, of the 31 significant policies for race, 20 participants were biased toward giving African American patients higher ratings, and 11 were biased toward giving Caucasians higher ratings. These individual differences in cue use are important and would have been missed had we limited the current study to only nomothetic analyses. Most healthcare providers will see hundreds of patients throughout their career. Consequently, a given provider with one or more consistent biases could negatively impact the care of many patients in pain. Moreover, because healthcare providers often assist in training both students and other providers, such biases could easily be transmitted in educational activities.

Regarding training, it appears that students reported receiving a moderate amount of training in how to assess pain, had a moderate amount of familiarity with pain conditions, and had a moderate amount of competency in pain assessment. However, there was wide variability in self-reported amount of training, familiarity, and competency. Since students were recruited from first, second, third, and fourth years in training, many of the students may not have reached the timing in the curriculum when they would receive training in pain assessment. However, it appears that the majority of the participants reported having seen a patient with chronic lower back pain, which suggests our vignette was relevant.

The results of this study could inform future education and clinical practices. For example, since some healthcare students appear to make decisions about patients based on sex, race, and age, it might be beneficial to identify those individuals and train them on how to be aware of their biases and how to prevent them from adversely affecting their clinical decisions. An identified person could be advised, for example, to make pain assessment and treatment decisions only after reviewing a range of objective and subjective measures relevant to pain, such as physiological parameters, medical history, patient self-report, and presenting problem. It may also be beneficial for that individual to consult with a colleague determine if their respective assessment and treatment decisions are consistent.

This study has several limitations that bear consideration. The chronic low back pain vignette was consistently used across participants and a different presenting pain condition may also have changed the results entirely. Moreover, the sample in this study was relatively homogenous, composed of young, well-educated individuals; therefore, the results may not apply to other groups. We also clustered healthcare students into a single cohort; there may be differences across healthcare groups but this exploration was beyond the scope of the present study. Another limitation concerns the VH themselves, in that they were limited to only facial expressions of pain. Actual clinical patients typically express their pain via verbal report and/or non-verbal behaviors; however, these expressions could not be presented with the VH stimuli employed herein. One reason for this is that it was not feasible to have more than four cues of interest in the current study. Each time a cue is added, the number of patient profiles that need to be created increases, which heightens participant burden (Cooksey, 1996). Human cognitive limitations also place constraints on the number of cues that may be presented to participants (Miller, 1956). Thus, the number of cues must be limited for a given study.

In summary, nomothetic analyses revealed that VH who were female, African American, older, and with high pain expression received higher ratings in most domains of interest than male, Caucasian, younger, and low pain expression patients, respectively. Idiographic analyses revealed individual differences in decision-making policies that were not captured by the nomothetic analyses. Encouragingly, however, it appears that healthcare students use pain expression cues as the largest contributor to their decisionmaking about pain. Future studies would likely benefit from using full-body VH in order to achieve more realistic depictions of actual patients. Important pain behaviors, such as bracing, guarding, and rubbing, could be represented through such full-body character. Furthermore, other populations of individuals involved in healthcare should be investigated, such as physicians, dentists, and pharmacists. In addition, it would be helpful to recruit a diverse sample in order to examine whether participant demographic characteristics affects pain ratings.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Demographic and healthcare characteristics of participants

	N	% of total
Sex		
Female	83	77.6%
Male	24	22.4%
Race		
Caucasian	74	69.2%
Hispanic	10	9.3%
Asian	10	9.3%
African American	3	2.8%
Indian	3	2.8%
Other	6	5.6%
Marital Status		
Single	88	82.2%
Married	13	12.1%
Living with partner	5	4.7%
Divorced	1	0.9%
Healthcare Area		
Physical Therapy	34	31.8%
Nursing	30	28.0%
Medical	25	23.4%
Dental	18	16.8%

Table 2

Educational program and year in class

Year in program	Dental	Medical School	Nursing	Physical Therapy	Total
1	5	8	15	2	30
2	8	3	3	19	33
3	3	5	2	13	23
4	2	9	10	n/a	21
Total	18	25	30	34	107

Table 3

Nomothetic Analyses: Mean and standard deviation of rating at the individual cue level for each decision domain.

Cue		Pain Intensity	Pain Unpleasantness	Negative Mood	Coping	Recommend Medical Help
		Decision Domain				
Sex	Male	33.24** (15.60)	35.00** (15.36)	32.37** (15.36)	28.85** (14.13)	48.07** (24.11)
	Female	**36.86**** **(16.11)**	**39.54**** **(15.75)**	**37.23**** **(15.64)**	**33.69**** **(15.10)**	**51.18**** **(24.29)**
Race	Caucasian	33.54** (15.49)	36.09** (15.39)	33.73** (15.23)	30.87 (14.58)	48.66** (24.87)
	African American	**36.56**** **(16.34)**	**38.46**** **(15.73)**	**35.87**** **(15.80)**	31.67 (14.73)	**50.60**** **(23.99)**
Age	Young	32.84** (17.49)	35.14** (14.37)	32.62** (14.41)	29.16** (13.17)	47.05** (24.11)
	Old	**37.26**** **(17.41)**	**39.40**** **(17.06)**	**36.98**** **(17.06)**	**33.38**** **(16.55)**	**52.20**** **(25.02)**
Pain	Low Pain	21.49** (14.54)	22.68** (14.27)	21.36** (14.53)	19.30** (12.96)	38.64** (26.60)
	High Pain	**51.86**** **(19.40)**	**51.86**** **(19.40)**	**48.25**** **(18.65)**	**43.24**** **(18.65)**	**61.22**** **(24.59)**

** indicates a significant within-cue difference $p < .01$

Table 4

Idiographic Analyses: Number of participants who had significant policies at the individual cue level for each decision domain ($p < .05$)

		Decision Domain ($p < .05$)					
Cue		**Pain Intensity**	**Pain Unpleasantness**	**Negative Mood**	**Coping**	**Recommend Medical Help**	**Total**
Sex	Male	1	0	0	0	0	1
	Female	6	11	13	13	9	52
Race	Afr. Am.	7	5	3	3	2	20
	Caucasian	1	3	3	3	1	11
Age	Young	1	2	1	2	0	6
	Old	16	16	16	15	17	80
Pain	Low Pain	0	0	0	0	0	0
	High Pain	93	95	94	87	76	445

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Table 5

Percent of variance in decision policies explained by contextual cues

	Pain Intensity Mean (*SD*) Range	**Pain Unpleasantness Mean (*SD*) Range**	**Negative Mood Mean (*SD*) Range**	**Coping Mean (*SD*) Range**	**Recommend Medical Help Mean (*SD*) Range**
Sex	.08 (.04)	.10 (.03)	.11 (.05)	.08 (.03)	.12 (.04)
	.03-.12	.05-.16	.06-.23	.04-.14	.07-.18
Race	.10 (.06)	.11 (.05)	.10 (.05)	.10 (.04)	.15 (.06)
	.04-.22	.07-.23	.07-.20	.03-.16	.11-21
Age	.15 (.10)	.13 (.09)	.13 (.10)	.14 (.08)	.16 (.10)
	.04-.37	.04-.37	.06-.46	.04-.34	.04-.45
Pain Expression	.52 (.18)	.51 (.19)	.49 (.17)	.47 (.18)	.46 (.18)
	.19-.90	.10-88	.18-.85	.14-.79	.07-.79
Total	.60 (.15)	.60 (.15)	.57 (.15)	.55 (.16)	.55 (.14)
	.29-.90	.30-.88	.30-.86	.30-.83	.30-.85