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Evaluating the Differences in Emotional Response to Affective Haptic Cues Between Populations

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I. Introduction

Individuals with mental health disorders employ emotion regulation techniques to aid in response modulation [3]. Affective Haptic System Design (AHSD) is focused on developing haptic technologies that sense or display touch cues intended to influence the affective state of the user [1]. Given the rise in availability of compact, low-power, and wireless technology, and owing to the high tactile sensitivity of the hand and wrist, wearable haptic devices are seeing greater adoption [1], [2] as a means to support emotion regulation. There is great potential for wearable haptic devices that convey affective haptic feedback to support response modulation for individuals with mental health disorders implementing emotion regulation techniques [3].

Despite this potential, there is limited research on the differential response to affective haptic stimuli across diverse populations. Papers within the affective haptic field have not consistently analyzed the participant pool in relation to age or cultural background. Of the 110 studies surveyed by Vyas et al. [1], 23 specified recruiting from university students and 2 from medical patients or persons with disabilities. Because emotion regulation techniques are often employed by individuals with unique experiences, for example, due to trauma, substance abuse, or addiction, it is necessary to understand how these prior experiences might influence an individual's response to haptic cues intended to elicit affective responses.

In this work, we explore the differential response of two populations to affective haptic cues, displayed via a wrist-worn device, that are designed to be calming or agitating. One population is individuals with Opioid-Use Disorder (OUD) who are likely to exhibit hyper-arousal which may affect their emotional response to affective haptic cues. We compare this population to a population of university students with no declared OUD. We measured the emotional response of participants in these two group using the dimensional approach. First, we measure *valence* (the pleasantness of an emotion), and second, we measure *arousal* (the bodily activation of an emotion) [4]. Valence and arousal responses are reported in the 2-D space of an arousal (y-axis) versus valence (x-axis) plot, and participant responses to each affective haptic stimulus are recorded using affective sliders [4].

The purpose of our study is to determine if cues designed to be calming or agitating elicited different emotional responses, and if the emotional responses differed between university student and OUD populations. We analyzed our results based on the following hypotheses.

(H1a) *The self-reported responses to the calming affect cues will have valence $>$ arousal.*

(H1b) *The self-reported responses to the agitating affect cues will have valence $<$ arousal.*

(H2) *The OUD population will have greater change in arousal ratings – further from neutral, more broadly, and will report higher arousal values than the university student population.*

II. Study Details

Twenty participants took part in this study, seven university student participants (2 female, age range 19 - 28, mean 22) and thirteen opioid-use disorder (OUD) participants (10 female, age range 29 - 64, mean 41). All participants provided their informed consent, and the protocol was approved by the Rice University Institutional Review Board (IRB-FY2022-7 and IRB-FY2024-89).

We used a Syntacts Bracelet (Fig. 1 (a)) [5] to provide haptic feedback. The bracelet contains four equally spaced linear resonant actuators (LRAs) (Vybronic Model Number VG1040003D) through which we display four emotionally evocative vibrotactile cues with frequency characteristics informed by literature on either social-touch and music affect (the $base$ of the cue). In pilot testing, these cues were shown to elicit calming (valence $>$ arousal) or agitating (valence $<$ arousal) affective responses. All cues were adjusted to have the same perceptual acuity, with a duration of 1.5 seconds, amplitude modulator of 1, and a carrying frequency at the resonance of the LRAs (170 Hz) [6].

There were two experimental blocks: exposure and testing. The participant wore the Syntacts bracelet on their non-dominant wrist throughout the experiment. The exposure block allowed participants to familiarize themselves with

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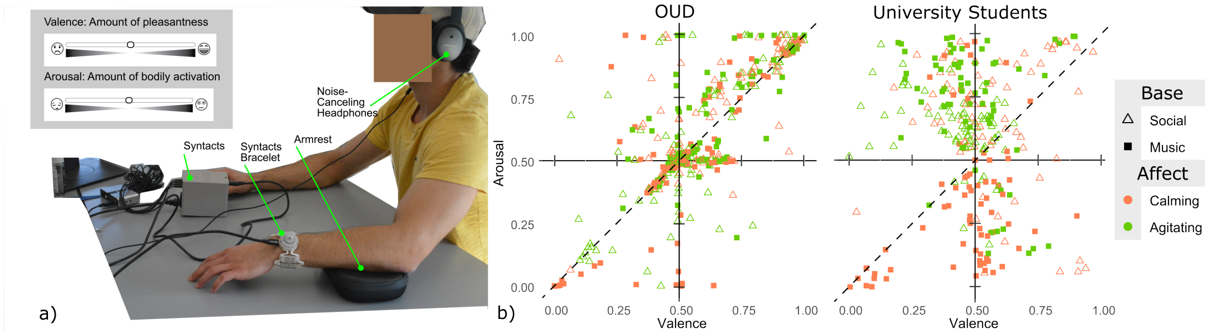

Fig. 1. We evaluated the emotional response of two populations (university students and individuals with OUD) to four affective vibrotactile cues. (a) Subjects wore a Syntacts Bracelet playing vibrotactile cues on their non-dominant wrist. They rated their emotional response for valence and arousal using affective sliders. (b) Valence-arousal responses to the four affective vibrotactile cues by population: opioid-use disorder participants (OUD) and university students. The x-axis shows their valence ratings, while the y-axis shows their arousal ratings. The shapes indicate the basis for the cue (social touch or music) , and the colors indicate the intended affect (calming or agitating). The dashed line marks where valence is equal to arousal.

the platform and the sensation of receiving haptic cues. They received three repetitions of three haptic cues (9 trials) unrelated to the testing cues and were asked to self-report their valence and arousal in response to the cues using affective sliders shown after each haptic cue (Fig. 1 (a)). The testing block used a similar protocol with ten presentations of each of the four affective cues (social touch or music base, calming or agitating affect) for a total of 40 trials.

III. Results and Discussion

Valence and arousal ratings of each affective haptic cue for each population are reported in Fig. 1 (b).

To test $H1a/b$, we conducted a one-sided t-test for emotion responses valence value minus arousal value. The difference between the valence and arousal ratings is derived from the placement of emotional categories on the valence-arousal-dominance-obstructiveness plot proposed by Schrer [7]. Here, positive values would indicate the cue was perceived as more calming, and negative values would indicate the cue was perceived as more agitating. Calming-music base cue responses trended towards calming (t(199) = 3.52, p < 0.001). Both agitating-social (t(199) = -5.1131, p < 0.001) and agitating-music (t(199) = -5.6671, p < 0.001) trended towards agitating. Calming-social base cues did not trend towards calming (t(199) = -3.15, p = 1.00).

To test for $H2$, we determined the Euclidean distance of the emotional response from neutral (0.5, 0.5) on the valence-arousal axes. A linear regression model (M1) was then created as follows:

M1: distance $\sim 1 + \text{affect} + \text{base} + \text{population} + (1 \mid \text{affect} + \text{base} + \text{population})$

Base ($\beta = -0.04, 95\% CrI = [-0.08, +0.00]$) and affect ($\beta = 0.04, 95\% CrI = [-0.00, 0.07]$) were not shown to be significant predictor for distance from neutral. Population was found to be a significant predictor of distance from neutral ($\beta = -0.07, 95\% CrI = [-0.11, -0.03]$), with the OUD population having emotion responses of greater distance from neutral. This is in line with our hypothesis, which was based on the phenomenon of hyper-arousal, a state of increased physiological and psychological activation in response to stress, which is present in substance-use disorder patients [8]. Additionally, the OUD population has emotional responses along the line of valence equals arousal (dashed in 1 (b). This could be due to differences in explanations from the study's experimenters, or their hyper-arousal causing a conflation of arousal and valence correlation.

IV. Conclusions and Future Work

We present initial findings from our study evaluating the difference in emotional response to vibrotactile cues for two populations, university students and individuals with OUD. We found that emotional responses trended towards the same affect (calming or agitating) for each population, while the university student population responded more neutrally. For future work, we will incorporate heart rate data during the experiment to understand the physiological differences in emotion response to the cues.

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