Mapping Vibrotactile Patterns to Emotions:
An Experimental Study on Intuitive Tactile Communication

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***Abstract*—Vibrotactile wearables have the potential to discreetly convey nonverbal emotional cues to people with visual impairments. However, many haptic approaches rely on arbitrary codes that require training. This evaluation study examines whether vibrotactile patterns can be intuitively associated with emotion labels without prior training, and assesses the emergence of stable dominant ("winner") emotions for individual patterns, to support accessible affective communication in human-computer interaction. In a controlled within-subjects experiment, 33 participants evaluated 14 patterns presented via a wrist-worn device. After each stimulus, participants selected one of seven emotion labels in a seven-alternative forced-choice task based on Paul Ekman's basic-emotions framework, including contempt. We tested recognition rates (target hits) and winner rates (most frequent label) against chance performance using one-sided exact binomial tests with Holm correction. Dominance was defined as the difference between the most frequent and the second-most frequent label. Three patterns showed a significant target mapping, while six patterns exhibited a significant winner emotion with high dominance. Overall, several vibrotactile patterns showed stable emotion associations without prior training and serve as candidates for further refinement and validation with users with visual impairments.**

Keywords—tactile communication; assistive technology; emotional communication; nonverbal communication; visual impairment.

I. INTRODUCTION

Nonverbal cues, such as facial expressions, gestures, and body language play a central role in the emotional classification of social situations [1]. However, people with visual impairments often have limited or no access to these cues, which can result in a loss of affective information in everyday life. Assistive sensory substitution approaches therefore aim to make visual emotional cues accessible via alternative sensory channels, ideally in a discreet manner and with as little cognitive load as possible [2][3].

The sense of touch is well suited in this context. Vibrotactile output systems can be discreetly integrated into wearables and do not require visual attention [2]. Research on affective haptics and mediated social touch suggests that the perception of haptic stimuli is not solely determined by the vibration itself, but significantly by the parameterisation of these vibrations, such as intensity, temporal structure, and dynamics. Thus, these parameters can systematically modulate perceived affective qualities [4][5].

A notable challenge is that many haptic communication approaches rely on conventionalised or arbitrary codes that require users to learn and stabilise their intended meanings [6][7]. This is especially problematic in situations where no visual reference or feedback channel is available, as it can significantly impair intuitive interpretability and usability [3].

This study examines whether vibrotactile patterns can be consistently assigned to specific emotion categories in a baseline sample without prior training. The conceptual framework of this study is based on the valence–arousal space (circumplex model), which describes affective states in terms of pleasantness (valence) and activation (arousal) [8]. Based on this framework, 14 vibrotactile patterns (two variants per emotion) were constructed to target seven emotion labels in line with Ekman's basic-emotions approach [1].

We conducted a controlled pre-study with sighted participants to establish a baseline mapping of 14 vibrotactile patterns to seven Ekman labels. We report recognition rate (target hits), winner emotion and winner rate (emergent mapping), and dominance Δ as indicators of mapping clarity, and we explore associations with empathy and vibration experience.

This exploratory baseline evaluation was conducted with a sighted sample, a low-fidelity prototype, and a no-training setup under controlled conditions. The findings provide an initial basis for refinement, but they do not yet allow direct conclusions about real-world assistive use.

The remainder of this paper is structured as follows. Section II reviews related work on affective haptics, the valence–arousal model, and Ekman's basic emotions as the conceptual foundation of the study. Section III describes the methodology, including the prototype, vibrotactile patterns, study design, measures, participants, and procedure. Section IV presents the results of the experimental evaluation. Section V discusses the findings, their implications, and limitations. Finally, Section VI concludes the paper and outlines directions for future work.

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II. RELATED WORK

A. *Affective Haptics and Vibrotactile Communication*

Affective haptics refers to haptic interaction design that aims to evoke affective experiences or convey emotional information [4]. In wearables, this is often implemented using vibrotactile signals, since they can be delivered close to the body, are suitable for everyday use, and work independently of visual attention [2][9]. The quality of a pattern is largely shaped by parameters, such as intensity, rhythm/pulse density, pauses, and ramp profiles [10][11].

A recurring challenge concerns the semantics of haptic signals. Many systems rely on tactile "vocabularies" or haptic icons whose meaning is not inherent, but becomes established through convention, training, or repeated use [10][11]. In assistive applications without a visual reference channel, this learning requirement is particularly challenging, as it can limit the immediate, intuitive interpretability of haptic patterns [2][3].

B. *The Valence–Arousal Model*

Affective perception is often described in a two-dimensional space defined by valence (pleasant–unpleasant) and arousal (activated–calm/sleepy). Russell's circumplex model describes affective states as combinations of these two basic dimensions and offers a continuous framework for positioning and varying stimuli [8].

This framework is well suited to vibrotactile stimuli because parameters such as intensity, pulse density/rhythm, pauses, and dynamics can be operationalised as carriers of arousal and, indirectly, valence. Empirical studies on the emotional effects of haptic parameters suggest that changes in intensity and temporal structure can lead to systematic shifts in ratings within the valence-arousal space [4][5].

C. *Ekman's Basic Emotions*

In addition to dimensional models, emotions are frequently characterised as discrete categories. Ekman's basic-emotions framework proposes a core set of emotions that are relatively stable and functionally meaningful, with distinct patterns of response and expression that can be modelled as qualitatively different states. The extant literature on the subject commonly refers to six basic emotions: happiness, sadness, anger, fear, surprise, and disgust [1]. Following prior empirical work that treats contempt as a distinct category, we included contempt as an additional label in the target set [12].

In this study, seven emotion labels (including contempt) are used as the target set for assignment in order to test whether vibrotactile patterns can be categorised intuitively at the label level. Valence and arousal are additionally used to locate the perceived effect of each stimulus within a dimensional space and to describe pattern profiles in a comparable way.

Specifically, this study makes two contributions. First, it introduces a structured evaluation framework for training-free vibrotactile emotion mapping based on recognition, emergent winner emotions, and dominance (Δ). Second, it provides empirical baseline evidence on parameter configurations that yield robust above-chance emotion associations.

Against this background, three Research Questions (RQs) are formulated, focusing on target assignment, dominance, and person-specific influencing factors:

RQ 1: Do individual vibrotactile patterns, without prior training, achieve assignment to the intended Ekman target emotion above chance level?

RQ 2: Which emotion category is selected as the dominant choice for each pattern, and how robust is this dominance?

RQ 3: Are trait empathy and experience with vibrotactile feedback associated with individual recognition rates? (exploratory)

III. METHODOLOGY

A. *Prototype and Vibrotactile Patterns*

The study used a low-fidelity prototype as the vibrotactile output system. The device uses two vibration motors integrated into an elastic wristband worn on the non-dominant wrist. One motor is placed on the upper side of the wrist, while the second is positioned on the underside. Control is handled by an ESP32-based microcontroller connected via Universal Serial Bus (USB) to a control unit. An administration unit is used to trigger the predefined patterns during the study. A motor driver ensures that the motors are supplied with sufficient current. The firmware was implemented in the Arduino development environment. Figure 1 shows the wristband prototype.

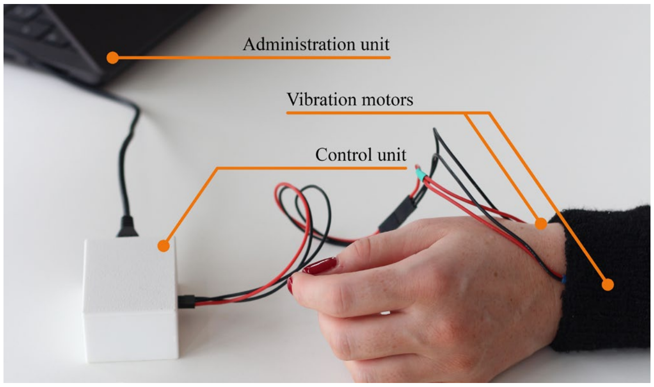

Figure 1. Wristband prototype with control unit, administration unit, and two vibration motors.

The vibrotactile patterns were specified as combinations of intensity, pulse duration, pauses, and the time course of intensity (ramp profile) [6][10]. Intensity was implemented using 8-bit Pulse-Width Modulation (PWM) in a range from 0 to 255. In the context of pattern design, three intensity levels were employed (low: 125 PWM, medium: 190 PWM, high: 255 PWM). Furthermore, separate time intervals were

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defined for pulse duration and pauses (short: 300 milliseconds, medium: 600 milliseconds, long: 900 milliseconds). In order to model different dynamics, both linear and exponential ramp profiles were applied.

The stimulus set comprised 14 vibrotactile patterns, with two variants created for each of the target emotions (six basic emotions, plus contempt) [1][12]. The development of the patterns was guided by the dimensions of valence and arousal, which are widely considered core factors of affective states [8]. This broad parameterisation was considered appropriate for an exploratory study, as prior work suggests that the affective interpretation of haptic stimuli is shaped by both stimulus parameters and context [4][5].

Patterns intended to convey higher activation were typically operationalised using higher intensities, shorter intervals, and more pronounced pulse sequences. In contrast, low-activation patterns were characterised by longer, calmer temporal profiles and lower intensities [4][5]. The specifications of all 14 patterns are summarised in Table I.

To illustrate theory-driven parameterisation along the valence–arousal space, three patterns are briefly described. We assume arousal is primarily encoded via intensity, pulse density, and temporal dynamics, whereas valence is influenced more indirectly by qualitative dynamics (e.g., smooth/fading vs. abrupt/jerky) [4][5].

Pattern 4 (Sadness B) was defined as a linear ramp-down from medium intensity (190 PWM) to 0 over 900 ms (R ↓ lin(M→0,900)). The continuous fade without repeated pulses reflects low arousal and a dampened signal character [4][5][8].

Pattern 9 (Surprise A) consisted of three short pulses with very short pauses (P(S,300)+p150+P(S,300)+p150+P(H,300)), culminating in a high-intensity pulse. The burst-like structure and abrupt intensity increase operationalise high arousal (startle/orienting), while valence remains context-dependent, consistent with surprise being potentially positive or negative [4][5][8].

Pattern 11 (Disgust A) consisted of three ramp-and-pulse segments with a medium – high – medium intensity structure ([R ↑ lin(0 → M,600)+P(M,300)] + p150 + [R ↑ lin(0 → H,600)+P(H,300)] + p150 + [R ↑ lin(0 → M,600)+P(M,300)]). The repeated build-ups and the dominant high-intensity middle segment reflect medium-to-high arousal and a more irregular signal character. The flanking medium-intensity segments before and after the peak were intended to avoid a single alarm-like burst and instead create a structured rise–peak–decline profile, which was considered more suitable for approximating disgust within the valence–arousal framework [4][5][8].

Before the study, the programmed patterns were repeatedly checked on the prototype through direct tactile inspection to confirm perceptible differences and reliable motor function. No external calibration was undertaken to verify a linear relationship between PWM input and physical actuator output.

TABLE I
OVERVIEW OF VIBROTACTILE PATTERNS

ID	***Target emotion***	***Parameters***	***Duration (ms)***
1	Happiness A	2×[2×P(M,300)+p150]+p300	1800
2	Happiness B	R↑lin(0→M,600)+p300+2×P(M, 300)+p150	1650
3	Sadness A	P(S,900)+p450+P(S,900)	2250
4	Sadness B	R↓lin(M→0,900)	900
5	Anger A	P(M,300)+p150+P(H,300)+p150 +P(S,300)+p150+P(H,300)	1650
6	Anger B	R↑exp(0→H,600)+D(H,900)	1500
7	Fear A	4×[P(H,300)+p150]	1650
8	Fear B	(P(M,300)+p150+P(H,300)) + p150 + (…) + p300 + (…)	2700
9	Surprise A	P(S,300)+p150+P(S,300)+p150+ P(H,300)	1200
10	Surprise B	(P(H,300)+p150+P(M,300)) + p300 + (…)	1800
11	Disgust A	[R↑lin(0→M,600)+P(M,300)] + p150 + [R↑lin(0→H,600)+P(H,300)] + p150 + [R↑lin(0→M,600)+P(M,300)]	3000
12	Disgust B	P(H,600)+p300+R↓lin(H→M,600)+p150+R↓exp(M→S,600)	2250
13	Contempt A	R↑lin(0→S,600)+D(S,300)+R↑lin(S→M,600)+D(M,600)	2100
14	Contempt B	R↑exp(0→M,900)+D(M,600)	1500

PWM levels: S = 125 (low), M = 190 (medium), H = 255 (high); P(x,t) = Pulse with intensity x and duration t ms; D(x,t) = Continuous vibration (constant) with intensity x and duration t ms; p = Pause (ms); R↑/R↓ = Ramp up/down; lin/exp = Linear/exponential.

Variations in total duration reflect the underlying parameter combinations (pulse lengths, pauses, and ramp segments) and were not controlled as a separate variable in this exploratory design.

B. Study Design and Measures

1) Study Design

The study used a within-subjects design. Each participant evaluated all 14 vibrotactile patterns, which helped reduce potential sources of variance caused by individual differences, such as general response tendencies or differences in tactile sensitivity [13]. Each trial presented one pattern followed by a standardised questionnaire. The aim was to capture an immediate, experience-based assignment for each pattern. Patterns were presented in a randomised order for each participant to minimise order effects [13]. Participants were allowed one optional repeat per pattern if needed.

2) Measures and Operationalisation

a) Measurements per trial

The primary dependent variable was the emotion assignment in a forced-choice format (ekman_choice). Participants were instructed to select one of seven emotion labels (happiness, sadness, anger, fear, surprise, disgust, and contempt) [1][12]. This response format was chosen to capture the assignment as a categorical decision and to test pattern recognition statistically against a defined chance level [14]. The order of response options was randomised to minimise position and order effects [15].

To encourage intuitive responses, the emotion category was collected first in each trial. Participants then rated their confidence in the assignment using a 5-point Likert-type scale (choice_confidence; 1 = very unsure to 5 = very sure) [16]. This measure adds a metacognitive judgement to the forced-choice assignment and indicates whether patterns are selected with low or high conviction [17].

Next, the affective dimensions valence and arousal were collected using two 5-point scales adapted from the Self-Assessment Manikin (SAM), but without the dominance dimension [18]. Valence was assessed with the question "How pleasant or unpleasant was the vibration pattern?" (valence; 1 = very unpleasant to 5 = very pleasant). Arousal was assessed with "How calm or arousing/activating was the vibration pattern?" (arousal; 1 = very calm/sleepy to 5 = very arousing/activating). Omitting the dominance dimension reduced the number of items per trial and lowered participant burden in a repeated-measures design [14]. In addition, many models treat valence and arousal as the central dimensions for describing affective states [8].

Final trial order: (1) ekman_choice → (2) choice_confidence → (3) valence → (4) arousal

b) Measurements per test subject

Two additional criteria were collected to describe the sample and to capture potential moderating or explanatory variables: (i) experience with vibrotactile feedback in everyday life and (ii) empathy. Experience with vibrotactile feedback was measured using five Likert-type items (including one reverse-coded) to capture everyday familiarity as a potential covariate. Empathy was assessed using the Single Item Trait Empathy Scale (SITES) to provide a compact measure of a dispositional trait that may relate to processing affective information [19]. In addition, demographic variables (age, gender) were recorded to describe the sample and to identify potential confounding factors (e.g., age-related differences in tactile perception) descriptively.

Pre-trial measures: (1) gender → (2) age

Post-trial measures: (1) vibration_experience → (2) empathy

3) Control of Potential Confounding Factors

To minimise order effects (learning, fatigue, or contrast effects), the sequence of the 14 patterns was presented in a randomised order for each participant [13].

Before the trials, the experimenter checked fit and motor placement and provided standardised instructions to ensure comparable stimulation conditions. Furthermore, participants were permitted only one repeat per pattern to avoid distorting the original intuitive assignment through frequent replays. Repeats were recorded and used as a quality metric (e.g., potential indications of low perceptibility for particular patterns).

C. Participants and Session Procedure

a) Participants

The sample consisted of N = 33 sighted participants. A baseline sample of sighted participants was employed in order to establish statistically robust stimulus-emotion associations under controlled conditions, prior to validation with visually impaired users. Participants were recruited as a convenience sample of sighted adults for this baseline study. No further selection protocol or stratification based on specific target characteristics was applied. The study was conducted as a supervised experiment, with an experimenter present throughout. Participants were aged 21 to 62 years; 45.45% identified as female and 54.55% as male. Each session lasted approximately 20–30 minutes per participant.

b) Study Setting and Setup

The data were collected in individual sessions. The prototype was fitted on the non-dominant wrist to ensure the dominant hand remained available for the completion of the questionnaire. The two vibration motors were positioned above and below the wrist, and stabilised using an elastic fixation similar to that of a sweatband.

The stimuli were triggered via a laptop using a Wizard-of-Oz setup, allowing the experimenter to play the predefined patterns in a controlled manner [20].

c) Session Procedure

At the beginning of the experiment, the subjects were given an introduction to the aim of the study and the procedures they would be expected to follow. They were also given information on the voluntary nature of their participation, the right to withdraw at any time, and the confidentiality of their data. The subjects then provided their signature on an informed consent form. In the subsequent phase of the experiment, the researcher affixed the prototype to the non-dominant wrist and conducted a meticulous evaluation of its fit.

The participants initially completed a brief questionnaire that solicited demographic information. Two neutral practice trials were conducted to familiarise participants with the sensation and response format and excluded from the analyses. Subsequent to this, the 14 vibrotactile patterns were presented in a randomised order. In each trial, participants initially made a forced-choice assignment to an Ekman emotion, followed by a confidence rating, and subsequently valence and arousal ratings. If needed, each pattern could be repeated once. Repeats were logged to capture potential perceptual issues. After completing all trials, participants answered questions about their experience with vibration signals and an empathy item. Finally, the prototype was removed and the session ended.

IV. RESULTS

A. Dataset and Analysis Strategy

The analysis is based on N = 33 participants who each evaluated 14 vibrotactile patterns (462 test trials). Two neutral practice trials were excluded from all analyses. After data collection, the dataset was screened for completeness and plausibility, then cleaned and coded. Per trial, the emotion label was treated as a categorical variable, while confidence, valence, and arousal ratings were coded as Likert-type values (1–5) [16]. For analysis, we derived pattern ID, target emotion, and a correctness indicator (target hit). In addition, we summarised valence and arousal at the pattern level using means and standard deviations and reported repeat frequency as an indicator of perceptibility. For the binomial tests, significance was evaluated one-sided because effects were hypothesised as above-chance mappings. Effect sizes are reflected by the observed proportions (recognition/winner rates) and the dominance gap Δ. Data preparation and metric calculation were conducted in Microsoft Excel; statistical analyses were performed in Jamovi.

To address RQ1 and RQ2, we computed two pattern-level metrics: recognition rate as the proportion of target hits (k_{target}/33) and winner rate as the proportion of the most frequently selected label (k_{winner}/33; emergent mapping). Both were tested against chance level p0 = 1/7 using one-sided exact binomial tests [14]. Holm correction was applied across the 14 patterns separately for recognition tests (p_{rec}) and winner tests (p_{win}) to control the family-wise error rate at $\alpha = .05$ [21]. Mapping clarity is reported via the runner-up label and dominance $\Delta = n_{winner} - n_{runner\text{-}up}$. Repeats were analysed descriptively. Exploratory Spearman correlations tested mean confidence vs. recognition rate (pattern level) and participant recognition vs. empathy/vibration experience (participant level) [14].

B. Recognition Rate: Assignment to the Target Emotion

After Holm correction, three patterns exceeded chance-level target assignment: Sadness A (ID 3: 51.52%, 17/33), Sadness B (ID 4: 57.58%, 19/33), and Surprise A (ID 9: 36.36%, 12/33) (Table II). Aggregated across variants, sadness showed the highest target assignment (54.5%, 36/66), whereas disgust (10.6%, 7/66) and fear (12.1%, 8/66) were lowest.

C. Winner Emotion and Mapping Robustness

To capture emergent mappings, we report the most frequently selected label per pattern (winner emotion) and its winner rate (Table II). Winner emotions can diverge from the intended target. After Holm correction, six patterns showed winner rates above chance (IDs 2, 3, 4, 5, 8, 9). Mapping clarity was quantified using dominance Δ. Sadness patterns were strongly dominant (ID 3: Δ = 11; ID 4: Δ = 14), whereas ID 8 (anger; Δ = 6) and ID 9 (surprise; Δ = 5) showed moderate dominance. ID 13 showed no clear winner (Δ = 0).

D. Repeats and Choice Confidence

Repeats were rare (7/462 trials; 1.5%) and occurred once each for seven different patterns (IDs 1, 2, 4, 5, 11, 12, 14), indicating no systematic perceptibility issues. Pattern-level confidence was not associated with recognition rate (Spearman $\rho = -0.306$, p = .288; n = 14 patterns).

E. Affective Dimensions: Valence and Arousal

In addition to the emotion label, participants rated each pattern on 5-point scales for valence and arousal. Table III reports pattern-level means and standard deviations. Overall, arousal ratings varied more strongly across patterns than valence.

F. Participant Characteristics and Recognition Rate

At the participant level (N = 33), recognition rate (across all 14 patterns) was not correlated with empathy (SITES; $\rho = -0.006$, p = .975) or vibrotactile experience ($\rho = 0.013$, p = .943; Spearman).

TABLE II
RESULTS FOR VIBROTACTILE PATTERNS

ID	*Target emotion*	*Recognition Rate*	*p_{rec}*	*p_{rec}(Holm)*	*Winner emotion*	*Winner Rate*	*p_{win}*	*p_{win}(Holm)*	*Δ*	*Runner-up emotion*
1	Happiness	21.21% (7/33)	0.183	1.000	Surprise	27.27% (9/33)	0.038	0.264	2	Anger
2	Happiness	24.24% (8/33)	0.089	0.977	Surprise	36.36% (12/33)	0.001	0.015^{*}	4	Happiness
3	Sadness	51.52% (17/33)	< .001	$< .001^{***}$	Sadness	51.52% (17/33)	<.001	$< .001^{***}$	11◆	Happiness
4	Sadness	57.58% (19/33)	< .001	$< .001^{***}$	Sadness	57.58% (19/33)	<.001	$< .001^{***}$	14◆	Surprise
5	Anger	18.18% (6/33)	0.330	1.000	Happiness	33.33% (11/33)	0.005	0.042^{*}	2	Surprise
6	Anger	21.21% (7/33)	0.183	1.000	Surprise	24.24% (8/33)	0.089	0.444	1	Anger
7	Fear	15.15% (5/33)	0.518	1.000	Anger	30.30% (10/33)	0.014	0.113	2	Happiness
8	Fear	9.09% (3/33)	0.869	1.000	Anger	42.42% (14/33)	<.001	$< .001^{***}$	6◇	Happiness
9	Surprise	36.36% (12/33)	0.001	0.016^{*}	Surprise	36.36% (12/33)	0.001	0.015^{*}	5◇	Happiness
10	Surprise	15.15% (5/33)	0.518	1.000	Happiness	24.24% (8/33)	0.089	0.444	1	Anger
11	Disgust	12.12% (4/33)	0.713	1.000	Anger	21.21% (7/33)	0.183	0.549	1	Contempt
12	Disgust	9.09% (3/33)	0.869	1.000	Surprise	21.21% (7/33)	0.183	0.549	1	Fear
13	Contempt	21.21% (7/33)	0.183	1.000	Happiness	21.21% (7/33)	0.183	0.549	0	Contempt
14	Contempt	12.12% (4/33)	0.713	1.000	Surprise	27.27% (9/33)	0.038	0.264	4	Fear

Recognition Rate = Proportion of correct assignments to the target emotion (k_{target}/33); Winner emotion/Winner Rate = Most frequently selected emotion/(k_{winne}r/33); Runner-up Emotion = Second most frequently selected emotion; p-values: One-sided exact binomial tests against chance level p_0=1/7; Holm correction within each respective test family (m=14 Patterns) applied separately for p_{rec} and p_{win}. * p(Holm) < .05, ** p(Holm) < .01, *** p(Holm) < .001.; $\Delta = n_{winner} - n_{runner\text{-}up;}$ ◇ $\Delta \geq 5$ (moderately dominant), ◆ $\Delta \geq 8$ (strongly dominant), in case of a tie Δ = 0 (e.g., ID 13).

TABLE III
RESULTS FOR VALENCE AND AROUSAL

ID	*Target emotion*	*Valence, M (SD)*	*Arousal, M (SD)*
1	Happiness	3.36 (1.08)	3.85 (0.91)
2	Happiness	3.24 (1.00)	3.30 (0.95)
3	Sadness	3.42 (1.09)	2.36 (1.25)
4	Sadness	3.82 (1.07)	1.79 (1.08)
5	Anger	3.42 (1.06)	4.03 (0.88)
6	Anger	3.24 (1.12)	3.55 (1.03)
7	Fear	2.78 (1.24)	4.61 (0.56)
8	Fear	2.85 (1.37)	4.45 (0.62)
9	Surprise	3.33 (1.27)	3.91 (0.98)
10	Surprise	3.09 (1.10)	3.97 (0.77)
11	Disgust	3.12 (1.02)	3.73 (1.04)
12	Disgust	2.82 (1.21)	3.91 (1.07)
13	Contempt	3.15 (1.23)	3.06 (1.30)
14	Contempt	3.42 (1.09)	2.88 (1.17)

M = Mean; SD = Standard deviation.

V. DISCUSSION

This pilot study assessed the association of vibrotactile patterns with discrete emotion labels without prior training and examined the emergence of stable "winner" emotions at the pattern level. Overall, only a subset of patterns supported target-consistent mappings, yet several stimuli converged reliably on a dominant label. Given the current parameter space, a purely intuitive one-to-one mapping to seven emotion categories appears difficult, whereas data-driven selection of robust signals remains feasible for building an initial haptic vocabulary [6][7].

The present study should be interpreted as an exploratory screening of a relatively broad pattern space. This made it possible to compare multiple candidate patterns across seven target emotions, but it does not yet allow a precise assessment of which individual parameters were responsible for the observed effects.

Target-consistent assignments occurred primarily for patterns whose temporal-energy profile was distinctive. Overall, sadness appeared to be the most robust category in the present dataset, as both sadness patterns performed above chance and showed strong dominance in the winner analysis. In particular, the two sadness patterns were consistently recognized, aligning with their low-activation design (longer, calmer envelopes and reduced abrupt peaks) [5]. At the same time, dimensional ratings indicate that arousal is captured more directly by intensity, pulse density, and dynamics, whereas valence appears harder to encode [4]. The valence and arousal ratings further suggest that arousal was conveyed more clearly than valence in the present dataset. This is consistent with the circumplex perspective, in which categories in the same arousal region can be difficult to separate when a stimulus primarily communicates activation rather than pleasantness [8]. The recurring emergence of surprise as a winner label is compatible with this mechanism: salient, abrupt patterns may be interpreted as an orienting/startle-like signal when valence cues are weak [5][8]. From a design perspective, the winner-based view is practically relevant. Even when a pattern misses its intended target, a stable emergent mapping can still be leveraged as a reliable carrier of meaning in a tactile vocabulary [6][7]. A useful selection heuristic is the combination of winner rate and dominance Δ, because it captures both preference strength and separation from the runner-up. Patterns with high winner rate and moderate-to-high Δ are plausible candidates for a core set, while low-Δ patterns should be reparameterised to increase distinctiveness (e.g., stronger contrasts in timing, clearer dynamic "signatures," or additional cues beyond global intensity/rhythm) [10][11]. If the goal remains a seven-label emotion set, future iterations likely need more explicit valence coding or an interaction concept that provides contextual framing or brief familiarisation to stabilise meanings [6][7].

Nevertheless, several limitations should be considered. Results were obtained in a controlled pre-study with sighted participants using a low-fidelity wrist-worn prototype and a forced-choice task without training, which may limit transfer to real-world assistive use and to people with visual impairments [3]. In addition, overlapping categories (especially among negative, high-arousal labels) may be amplified by the seven-alternative forced-choice format when stimuli mainly convey arousal [8].

VI. CONCLUSION AND FUTURE WORK

This study provides a baseline mapping of 14 vibrotactile patterns to discrete emotion labels under no-training conditions and introduces a pragmatic screening approach based on winner rate and dominance Δ. The results indicate that some patterns can support stable, training-free associations, while many mappings are dominated by arousal-related interpretations, suggesting that valence is comparatively harder to convey via the current parameterisation. Further work should address four directions. First, the stimulus set should be iteratively optimised using the observed winner/Δ profiles: retain robust patterns, redesign ambiguous ones, and explicitly test parameter changes intended to improve separability (e.g., timing contrasts, dynamic ramps, or additional distinguishing cues). This next step should reduce the pattern space and test simplified stimulus families before moving to more complex combinations. Second, validation with people with visual impairments is required, including calibration (fit and intensity thresholds) and evaluation in context-relevant scenarios where meaning is used rather than only judged. Third, the role of minimal familiarisation should be tested systematically (e.g., short onboarding vs. none), measuring learning curves, retention, and potential cognitive load tradeoffs in repeated sessions. Fourth, future work may revisit the methodology used to select vibrotactile patterns and examine whether emotion interpretations are shaped not only by the stimulus itself, but also by the situation, social context, or recent stimulus history.

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