Affective Touch: Exploring Empathic Communication with Visually Impaired Children

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Abstract

This study investigates how children with visual impairments communicate affectively via touch and how they interpret vibrotactile feedback. Since visual stimuli can only be used to a limited extent, touch-based communication plays a central role in perception and social interaction for these children. Two children (aged 14 and 15) engaged with: (1) a *Sensor Bear* to express emotions through touch, (2) an *Actuator Bear* to decode vibration patterns, and (3) a *Conventional Bear* for free exploration and personal preferences. This empathy-centric approach facilitates affective communication through tangible mirroring of affective states between remote partners. Findings reveal diverse touch preferences, the essential role of material softness for affective expression, mixed success in vibration pattern interpretation, and challenges in imagining remote affective scenarios.

Keywords

Affective interaction, Vibrotactile communication, Accessibility, Visual impairment, Tangible interaction, Empathy-centered design, Haptic interfaces

1. Introduction

Children with visual impairments rely heavily on tactile and bodily communication for social and emotional interaction, as visual cues are largely inaccessible. This study exploratively investigates how they express affect through touch and interpret vibrotactile feedback, opening new possibilities for remote emotional connection.

This work is positioned in the field of affective interaction [1, 2, 3], as it treats emotions as socially interpretable and enacted through interaction. Our study contributes to empathy-centered design by centering the affective interactive experiences of children with visual impairments and exploring how tactile interaction can support both affective expression and interpretation. By foregrounding non-visual channels of social interaction, we highlight how empathic processes may be mediated through touch in remote contexts.

This study focuses on interaction with three different stuffed bears: one is equipped with sensors to detect touch (*sensor bear*), another with actuators that provide feedback (through vibration; *actuator bear*), and a third without technology (*conventional bear*). The children were encouraged to express and interpret patterns associated with emotions through touch and vibration, and were asked about design preferences for future stuffed animals intended for remote emotional communication.

2. Related Work

2.1. Understanding Affective States

Communicating one's emotional experiences and understanding the emotions of others are fundamental aspects of social interaction. The term *affect* serves as an umbrella concept that encompasses different

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types of affective experiences, including short-term affective states and longer-lasting emotions. One of the most influential frameworks for conceptualizing affective states is the *Circumplex Model of Affect* proposed by Russell. This two-dimensional model describes affective experiences along the continuous dimensions of valence (pleasant–unpleasant) and arousal (low–high activation) [4], rather than assuming a set of universal, discrete emotion categories as introduced by Ekman [5], or adopting hybrid approaches such as the Geneva Emotion Wheel developed by Scherer [6].

While these models provide a theoretical framework for better structuring and therefore understanding affective states, they do not specify how such states can be operationalized, perceived, or communicated through interactive systems.

2.2. Non-Visual Communication of Affect

In HCI, the challenge of non-visual communication of affect has motivated research into alternative modalities—particularly tactile and vibrotactile interfaces—as means of encoding and decoding affective information.

Brewster and Brown introduced *Tactons*, tactile icons on displays, for non-visual communication. They can be understood as a tactile pulse that varies by frequency, amplitude, and duration [7]. Adding to this UrRehman and Liu built a mobile-phone system that encodes lip-based emotion information into tactually perceivable vibration patterns [8]. They further generalized this concept and showed that more than 1-bit emotional information can be rendered and interpreted via vibration[9].

Another line of work explores emotion-vibrotactile associations in the dorsal region. Villa et al. investigated how self-generated vibrotactile patterns in the dorsal region—varying amplitude, frequency, and spatial location—correspond to distinct emotional states (anger, happiness, neutral, sadness) [10]. Similiarily Arafsha et al. added heat and vibration actuators to a wearable haptic jacket to convey six basic emotions (love, joy, surprise, anger, sadness, fear) and social gestures (hug, poke, tickle, touch) [11].

A different line of work investigates wearable haptic devices that translate the emotional content of movies—particularly music—into vibrotactile feedback for hearing-impaired audiences [12]. Their findings show that combinations of vibration intensity and frequency can convey differences in high versus low arousal and valence. Similarly, *HiPalm* [13] explores palm-based affective touch through soft robotics. Worn on the hand, the device rhythmically inflates and deflates in response to proximity and the wearer's heart rate, mediating interpersonal affective states such as calm, neutral, and elevated activation.

These approaches primarily address either the transmission of affective signals (output) or their perception and decoding (input); our study brings these two perspectives together by examining affective interaction as a bidirectional process. Similar to Ju et al., who investigated how people not only communicate subjective feelings through vibrotactile feedback but also interpret such stimuli [14], we explore how visually impaired children both express affect through touch (*Sensor Bear*) and interpret vibrotactile cues (*Actuator Bear*). In doing so, we connect the expressive and interpretative dimensions of tactile affective communication.

3. Method

The study explores how children with visual impairments express and interpret emotions through tactile interaction with three different bear prototypes. Two children, aged 14 and 15, both male (grades 6 and 8), participated in individual sessions. Regarding visual impairment, one child was blind with residual vision, while one child had low vision. None of the participants was completely blind.

Each child interacted with three different prototypes or plush bears:

1. *Sensor Bear* – A plush bear instrumented with five polymer nanocomposite force sensors (NanoSen GmbH, Chemnitz, Germany), which were distributed across the head, snout, left paw, right leg, and stomach. The children were asked to imagine communicating emotions (joy, sadness, anger,

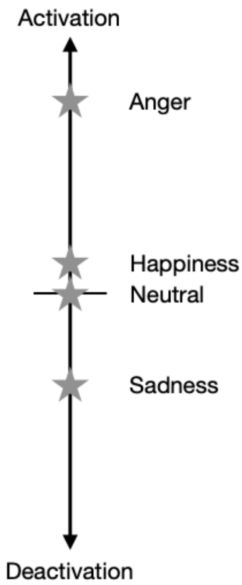

Figure 1: Activation levels for the affective vibration patterns, derived from Russell's Circumplex Model of Affect.

Table 1
Activation levels of each affect are mapped to specific motor patterns (duration and pulse configuration).

Affect	Activation	Duration (ms)
Anger	High	3 × 1000 (100 off)
Happiness	Moderately High	6 × 500 (100 off)
Neutral	Medium	200
Sadness	Low	3000

or neutrality) to another person through the bear, which acted as a haptic communication device. They could press, hug, or stroke the bear in any way they felt matched the emotion. During the interaction, force data were recorded via NanoSen electronics and logged to a computer using SerialPlot software [15]. *Note: Qualitative observations of children's interaction behavior and verbal reports are reported. Sensor data from the Sensor Bear were recorded but not quantitatively analyzed.*

2. *Actuator Bear* – A plush bear equipped with two mini vibration motors (located in the head and stomach) and an Arduino UNO R4 WiFi microcontroller. In this station, children took the receiver's perspective: instead of sending emotions, they experienced predefined vibration patterns triggered by the test administrator via a custom web-based interface [16]. Participants then indicated which emotion—joy, sadness, anger, or neutrality—they associated with each pattern. The vibration was perceivable throughout the entire bear.
3. *Conventional Bear* – A non-interactive plush bear used for open exploration and a semi-structured interview about emotional communication through plush toys.

Observations were noted to capture interaction behavior and verbal reflections.

The activation levels assigned to the four affective states to be identified during interaction with the *Actuator Bear* are illustrated in Figure 1. were informed by the arousal dimension of Russell's Circumplex Model of Affect [4]. The corresponding vibration patterns are specified in Table 1. Each pattern differed in its temporal structure, including duration and pulse configuration. Anger was implemented as pulsating bursts (three 1000 ms activations separated by pauses), happiness as rhythmic pulses (six shorter bursts), sadness as a prolonged continuous vibration, and neutral as a brief, steady stimulation.

4. Results

1. *Sensor Bear* – The two children showed individual preferences in how to express emotions through the bear. When imagining happiness, they either squeezed the bear's paws or wanted it to clap its paws. For sadness, they imagined lowering the bear's head or having it hug itself. When asked to represent a neutral emotion, they suggested the bear's paws to hang down but still struggled to find a meaningful way to interact and, at times, did not engage with the bear at all. Overall, they found it difficult to imagine the affective communication scenario, as the emotions were not actively induced.
2. *Actuator Bear* – While the children could partly make clear associations between the patterns and the four affects, they also found it challenging to connect vibration patterns to specific affective states.
3. *Conventional Bear* – The children commented on the bear's embraceable form, describing these qualities as essential for affective communication. When considering other potential plush toys for similar interactions, one child mentioned their favorite animal (lion), and the other emphasized the importance of compressibility, material softness and round shapes.

5. Discussion

The findings highlight individual interaction preferences and demonstrate the potential of temporally structured vibrotactile patterns for remote affective communication among children with visual impairments. Plush toys appeared to be a fitting object type for this user group, with compressibility and material softness identified as essential for expressive affective interaction. However, these qualities may not be inherently tied to plush toys. More generally, soft, comforting, and touch-responsive materials could serve as promising carriers for affective interaction, allowing adaptation to different age groups and preferences, including older children and adolescents.

By examining both expressive touch interaction and the interpretation of vibrotactile feedback, this work approaches affective communication as a bidirectional, embodied process. Participants' reported difficulties in imagining remote communication scenarios point to the importance of situated and reciprocal interaction for meaning-making. This suggests that dyadic study designs, in which two participants actively communicate with each other, may better capture the inherently relational nature of affective exchange. Such approaches could facilitate more naturalistic interactions and reduce the cognitive demands associated with imagining abstract communication contexts.

Furthermore, it would be valuable to explore the transferability of vibrotactile patterns to other sensory modalities. Exploring the transferability of vibrotactile patterns to other modalities, such as light- or sound-based signals, may help to determine whether affective information can be consistently conveyed across different channels. This line of inquiry is particularly relevant for accommodating diverse user needs and varying forms of impairment, and for advancing more inclusive approaches to affective interaction design.

Overall, the results suggest that affective communication through touch is strongly shaped by material qualities and interaction affordances, underscoring the importance of embodied and context-sensitive approaches for empathy-centered design.

6. Limitations and Outlook

A key limitation of this study is the small sample size, which limits the robustness and generalizability of the findings within the target population of children with visual impairments. Another limitation is the absence of emotion induction with validated stimulus material. As a result, participants' responses were based on imagined rather than lived affective experiences, which may have influenced expressive interactions. In addition, the vibration motor output was not actively varied in intensity. Greater control over vibration intensity could enable more differentiated and complex haptic patterns, potentially improving the distinction between affective states.

Future work should therefore focus on conducting a pattern discovery study using induced affective states to derive empirically grounded haptic patterns. Building on this, the discriminability of these patterns should be systematically evaluated. Furthermore, these patterns should be validated in dyadic settings to assess their effectiveness in supporting affective exchange between remote partners. Finally, technical refinements that allow continuous control of vibration intensity (e.g., via Pulse Width Modulation, PWM) should be implemented to expand the expressive range of the *Actuator Bear*.

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Declaration on Generative AI

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