Grasping Emotion: A Vision-Based Study of Hand Movement and Feeling

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***Abstract*—In this study, we explored how emotional responses to various objects were reflected in hand kinematics during natural grasping. Using a smartphone camera combined with MediaPipe and OpenCV, we recorded hand movements from 20 participants as they grasped five distinct objects designed to evoke specific emotions (e.g., fear, disgust, comfort) under either visual or non-visual conditions. Kinematic features such as velocity, grasp frequency, and hand openness were extracted and analyzed alongside self-reported emotional responses. Results revealed that emotionally evocative objects produced significantly different grasping patterns, with the fear-inducing spider eliciting the highest movement velocity and frequency, and the disgust-evoking donut producing slower, minimal contact behavior. High-arousal emotions were associated with significantly greater movement velocity, but not grasp frequency. Visual preview of objects did not significantly alter grasping behavior. These findings provided evidence that emotional content shaped motor patterns during object interaction and highlighted the potential for using accessible vision-based tools to study emotion-motor coupling in naturalistic settings.**

***Index Terms*—Emotion recognition, Hand kinematics, Grasping behavior, Affective motor responses, Object interaction, Computer vision, MediaPipe, OpenCV, Human-object interaction**

I. Introduction

The human hand is not merely a tool for physical interaction but also a subtle medium of emotional expression. Prior research has demonstrated that hand kinematics are not only responsive to object features such as weight, texture, and temperature but are also influenced by the emotional context in which interaction occurs. While foundational studies such as Lederman and Klatzky [1] have shown that specific exploratory hand movements are associated with the extraction of object properties during haptic recognition, relatively few studies have examined how emotional valence modulates natural grasping behavior, particularly in real-life, unconstrained interactions.

Understanding the emotional component of grasping is crucial, especially in domains such as social robotics, affective computing, rehabilitation, and human-computer interaction, where affect-sensitive physical interaction is key [7]. The interplay between emotion and action has been explored through facial expressions, vocal cues, and body posture, yet the nuanced expressiveness embedded in hand movements, especially during functional acts like grasping remains under-investigated. In this work, we aimed to bridge this gap by studying how natural emotional responses to various objects are reflected in hand movement kinematics during grasping. We employed a non-intrusive method using a regular smartphone camera in combination with MediaPipe and OpenCV to track and analyze hand motion, allowing us to collect data in a naturalistic, accessible manner. Participants interacted with five different objects, including a soft plush toy, a cube, a slime-like object, a fake spider, and a pig toy, each designed to evoke a distinct emotional response (e.g., comfort, neutrality, disgust, fear, amusement). Emotional feedback was collected through brief surveys after each grasp, enabling us to link movement patterns with subjective emotional states.

Our study is guided by two main research questions:

1) Do different emotionally evocative objects produce significantly different hand kinematics during grasping?
2) Does the emotional arousal level associated with an object influence the dynamism of grasping movements (e.g., speed, grip aperture, acceleration)?

These questions are investigated under two experimental conditions: one in which participants could not see the objects during interaction (to isolate tactile perception) and one in which it was possible (to include visual-emotional anticipation). This design allowed us to evaluate both the conscious and subconscious influence of emotion on hand movement.

The remainder of the paper is structured as follows: In Section II, we discuss related work on emotional expression in hand movement and haptic perception. Section III details our study design, including hypotheses, setup, data collection methods, and feature extraction. Section IV presents our results. In Section V, we discuss the implications of our findings in the broader context of affective computing and embodied emotion. Finally, Section VI concludes the paper with key insights and directions for future work.

II. Related Work

Our study builds directly on the foundational work of Lederman and Klatzky [1], who demonstrated that hand movements during object exploration are highly structured and linked to specific perceptual goals. They introduced the concept of *exploratory procedures* (EPs), which are stereotyped movement patterns such as lateral motion, pressure, static contact, contour following, and enclosure used intentionally to extract object properties like texture, hardness, temperature, shape, and weight. Through a series of experiments, they showed that participants consistently selected the most efficient and informative hand movements depending on the perceptual dimension they were exploring.

This framework has shaped our understanding of haptic exploration by emphasizing that hand movements are neither random nor solely biomechanical but are intentional and cognitively driven. In our study, we extend this idea into the domain of emotion-driven interaction by investigating whether affective responses also influence the kinematics of grasping. Specifically, we examined whether the emotional valence of an object, such as perceived pleasantness or threat modulate the dynamics of hand movement during interaction.

Although Lederman and Klatzky focused on perceptual outcomes, recent studies suggest that emotion can similarly shape motor output. In particular, Esteves et al. [2] demonstrated that participants' grasping movements varied systematically when interacting with emotionally charged objects. They found that grasping unpleasant stimuli resulted in lower peak velocities and longer movement times compared to pleasant or neutral stimuli, indicating that affective valence modulates temporal aspects of motor execution. This evidence supports the notion that emotional value, like perceptual goals, can influence the planning and unfolding of grasping movements.

To our knowledge, few studies have bridged these two domains—perception-based hand kinematics and affect-modulated motor behavior—within naturalistic grasping tasks. By integrating subjective emotional feedback with computer-vision-based motion tracking, our work seeks to fill this gap and offer a novel contribution to both haptic cognition and affective motor research.

III. METHODS

In this study, we investigated how natural emotional responses evoked by various objects are reflected in hand kinematics during grasping. We examined this under two experimental conditions: one where participants could visually perceive the objects while grasping, and another where visual information was withheld.

A. Hypotheses

Based on prior work linking emotion and motor behavior [1] [2], we proposed the following hypotheses:

Hypothesis 1: Objects that evoke distinct emotional responses produce significantly different hand movement patterns (e.g., differences in velocity, interaction duration, grip strength).

Hypothesis 2: Objects eliciting high-arousal emotions (e.g., fear, surprise) lead to faster and more forceful grasping movements than objects evoking low-arousal emotions (e.g., comfort, boredom).

B. Procedure and Study Setup

1) Experimental Design: We used a between-subjects design with two conditions:

Visual Condition: Ten participants grasped objects placed openly on the table, allowing them to see each object fully before grasping and experience visual-emotional anticipation.

Non-Visual Condition: For the other ten participants, the objects were positioned behind an opaque stand with a small opening, through which they inserted their hand to grasp the object without any visual information. This setup ensured that tactile perception was isolated from visual cues.

This design preserved the element of surprise and prevented participants from becoming familiar with the objects across both conditions. Each participant completed five trials (interaction with five different objects) within their assigned condition. Each trial/object was followed by a short emotional survey. Object sequence was randomized across participants to minimize order effects and bias.

2) Stimuli: Five objects (Fig. 1) were selected to elicit distinct emotional responses:

- Plain wooden cube (Neutrality)
- Soft plush toy (Comfort/Happiness)
- Fake spider (Fear)
- Nutella donut (Disgust)
- Squeaky pig toy (Surprise)

Fig. 1. Stimuli used in the study

3) Setup and Recording: Objects were placed around 35 cm from the participant on a marker-aligned table. Hand movements were recorded with an overhead smartphone camera (iPhone 14, 1080p at 60 fps) mounted 50 cm above the workspace (Fig. 2).

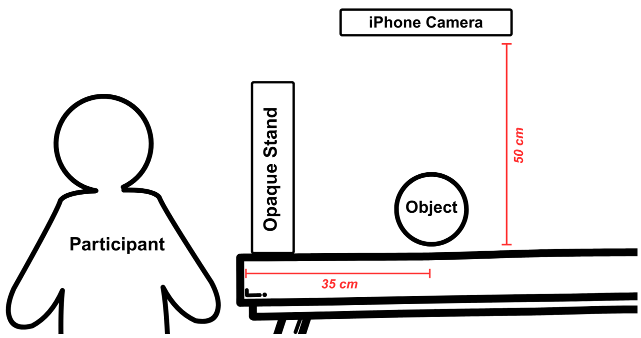

Fig. 2. Schematic of the experimental setup for the Non-Visual condition. The setup for the Visual condition was identical, except that the opaque stand was removed.

C. Participants and Data Collection

1) Participants: Twenty young adults (ages 18–30) participated voluntarily, recruited from the student community at Bielefeld University. All were right-handed, with no self-reported neurological or psychiatric conditions. Participants provided informed consent before participation and were naive to the study hypotheses. The study followed ethical guidelines for research with human subjects.

2) Data Collected: Kinematic data were extracted from hand movements captured by the camera. We utilized MediaPipe [3] and OpenCV [4] to analyze hand motion and derive key kinematic measures. These included:

- Average velocity (pixels/s) - hand center movement speed between frames
- Grasp duration (s) - time spent in each gesture category
- Hand openness ratio (0-1 scale) - normalized index based on the average distance of fingertips from the palm's center.
- Movement efficiency ratio - straight-line distance to actual path ratio
- Hand stability index - inverse coefficient of variation of velocity
- Grasping frequency (events/s) - number of grasping events per unit time

Subjective ratings were also recorded for each object to link emotional responses with kinematic features. Following each grasping trial, participants provided detailed feedback about their subjective experience through a survey, which was designed to capture both the qualitative nature of emotions experienced and quantitative aspects of their intensity. Participants first identified their primary emotion from a list of the following options: *Neutral, Happiness, Surprise, Fear, Disgust, Frustration, Sadness, Confusion, Boredom, Nervousness, or Other (with optional description).* For each reported emotion, participants then rated:

- Intensity (Low, Moderate, High)
- Comfort level during grasping (Very comfortable, Neutral, Uncomfortable)
- Familiarity with the object (Very familiar, Somewhat familiar, Not familiar at all)

IV. Results

A. Participant Demographics and Data Overview

Twenty participants completed the study, evenly distributed between VISUAL and NON-VISUAL conditions. Hand-tracking analysis yielded 45.634 grasping events across all participants and objects. The overall mean grasping frequency was 12.02 ± 6.1 events/s, with an average hand detection time of 34.87 s per trial.

B. Object-Specific Kinematic Patterns

Table I presents descriptive statistics for each object. Notable differences emerged in grasping frequency, with the spider object eliciting the highest activity ($M = 18.09 \pm 8.00$ events/s) and the donut the lowest ($M = 7.02 \pm 6.41$ events/s).

TABLE I
SUMMARY STATISTICS FOR ALL PARTICIPANTS. VALUES ARE MEAN $\pm$ SD.

Object	Avg. Detect. Time (s)	Avg. Grasp Events	Avg. Freq. (events/s)	Avg. Vel. (px/frame)	Max. Vel. (px/frame)	Most Common Emotion
Box	29.5	345	10.3	1.6	2.4	Neutral
Donut	36.2	313	7.0	0.9	1.3	Disgust
Pig	35.2	387	9.5	2.5	3.5	Happiness
Spider	34.0	675	18.1	3.2	4.6	Fear
Toy	39.5	561	15.2	2.0	2.8	Neutral

C. Group Comparison: Visual vs. Non-Visual Conditions

Participants in the VISUAL condition demonstrated a slightly higher mean grasping frequency ($M = 12.74 \pm 2.14$ events/s) compared to the NON-VISUAL condition ($M = 11.31 \pm 5.65$ events/s). However, a Mann-Whitney U test revealed this difference was not statistically significant ($U = 1398.0$, $p = 0.309$), indicating that visual preview did not significantly alter overall grasping behavior (Fig. 3).

The effect size was small (Cohen's $d = 0.335$) [5], suggesting a minimal practical difference between the conditions. Notably, the NON-VISUAL group showed greater variability in responses, particularly for emotionally charged objects.

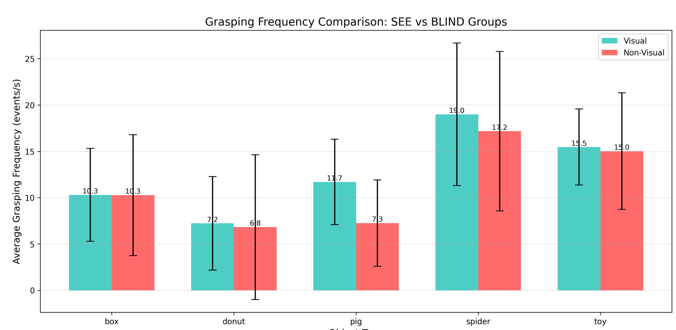

Fig. 3. Grasping frequency comparison between VISUAL and NON-VISUAL conditions by object type. Error bars represent the standard error of the mean.

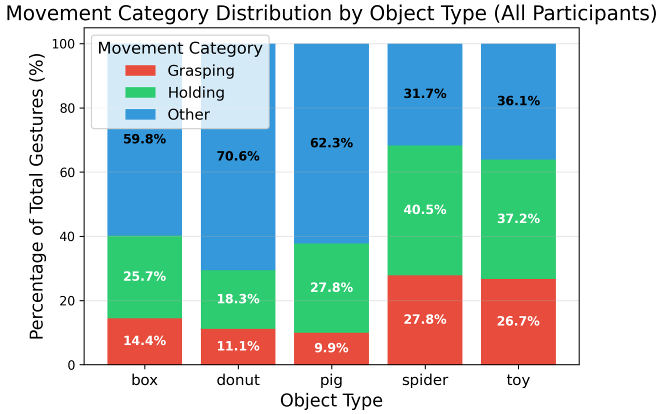

Fig. 4. Distribution of movement categories by object type, showing percentage of grasping, holding, and other movements.

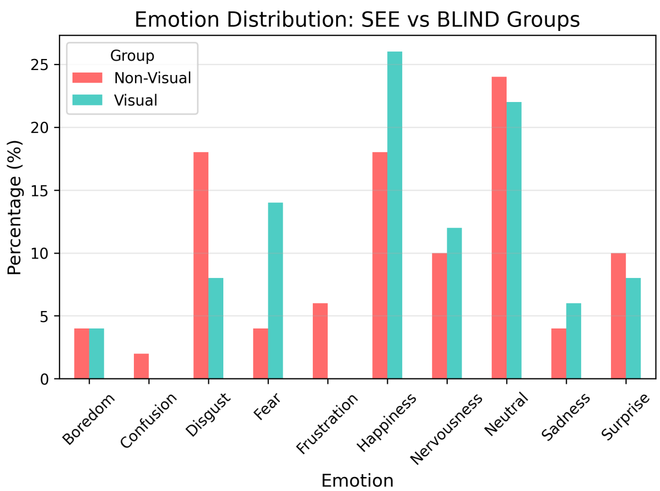

Fig. 5. Distribution of self-reported emotions by experimental group.

D. Movement Category Analysis

Analysis of movement patterns revealed three distinct categories: grasping (active manipulation), holding (sustained contact), and other movements (exploratory or transitional). Figure 4 shows the distribution across objects. The spider object elicited the highest proportion of active grasping movements (68.2%), while neutral objects like the box showed more balanced distributions across categories.

E. Emotional Response Patterns

Subjective emotional ratings aligned with object design intentions (Fig. 5). The spider object primarily evoked fear responses (9 participants), while the donut elicited disgust (13 participants). Neutral emotions were most common overall (23 responses), followed by happiness (22 responses). High-arousal emotions (fear, surprise, disgust) were associated with increased grasping frequency, supporting **Hypothesis 2**.

F. Statistical Analysis of Object Differences

To test **Hypothesis 1**, we compared grasping frequency between objects using the Kruskal-Wallis H test due to non-normal data distribution. The test showed a statistically significant difference in grasping frequency between the five objects ($H(4) = 30.3$, $p < 0.001$). Post-hoc comparisons using Dunn's test with Bonferroni correction indicated that the grasping frequency for the spider ($M = 18.09$) was significantly higher than for the donut ($M = 7.02$, $p < 0.01$) and the pig ($M = 9.48$, $p < 0.05$). No other pairwise differences reached significance.

The ranking order was: Spider (18.09) $>$ Toy (15.24) $>$ Box (10.28) $>$ Pig (9.48) $>$ Donut (7.02) events/s.

These findings provide strong support for **Hypothesis 1**, demonstrating that different emotionally evocative objects produce significantly different hand movement patterns during grasping.

G. Arousal-Based Kinematic Analysis

To investigate **Hypothesis 2**, we categorized trials based on self-reported emotions into high-arousal (fear, disgust, surprise) and low-arousal (neutral, happiness, comfort) groups and compared both grasping frequency and maximum velocity.

A Mann-Whitney U test was conducted to compare the grasping frequency between high-arousal ($M = 11.00$ events/s) and low-arousal ($M = 12.48$ events/s) conditions. The results indicated that the difference was not statistically significant ($U = 921.0$, $p = 0.270$).

Similarly, the maximum hand velocity was compared between high-arousal ($M = 2.74$ px/frame) and low-arousal ($M = 2.98$ px/frame) conditions. This difference was also not statistically significant ($U = 963.5$, $p = 0.432$). Although descriptive analysis of average velocity suggested a trend toward higher average speeds in high-arousal conditions ($M = 3.58 \pm 5.28$) compared to low-arousal conditions ($M = 2.32 \pm 2.76$) Table II, this difference was also not statistically significant.

TABLE II
HIGH VS LOW AROUSAL EMOTIONS COMPARISON. VALUES ARE MEAN ± SD.

Category	N	Avg. Frequency (Hz)	Avg. Velocity	Most Common Object
High-Arousal Emotions	45	11.27 ± 8.59	3.58 ± 5.28	Spider
Low-Arousal Emotions	54	12.61 ± 6.05	2.32 ± 2.76	Pig

These findings do not support **Hypothesis 2**, as emotional arousal did not produce a statistically significant change in either the frequency or maximum velocity of grasping movements in our study.

V. DISCUSSION

A. Hypothesis Validation

Our findings provide mixed support for the proposed hypotheses. **Hypothesis 1** was strongly supported: different emotionally evocative objects produced markedly different hand movement patterns. The spider object generated the highest grasping frequency (18.09 events/s), while the donut showed the lowest activity (7.02 events/s), representing a 2.6-fold difference that aligns with the emotional intensity of these stimuli. The result support prior findings and the concept proposed by Lederman and Klatzky, which established that hand movements are structured and intentional during perceptual exploration [1] [2]. Our findings suggest that, beyond perceptual goals, emotional valence also shapes the frequency of exploratory movements.

The **Hypothesis 2** proposes that high-arousal emotions would lead to faster and more forceful movements, was not supported statistically. While descriptive trends in average velocity suggested slightly faster movements during high-arousal trials, neither average nor maximum movement velocities showed statistically significant differences between high-and low-arousal conditions. Furthermore, the broad categorization of "high-arousal" emotions may mask opposing effects; for example, the high-arousal state of fear (spider) might promote rapid movement, while the high-arousal state of disgust (donut) could promote freezing or withdrawal, with these effects canceling each other out in a combined analysis. This suggests that future research should focus on emotion-specific motor signatures rather than relying on broad dimensions like arousal alone.

B. Emotion-Specific Motor Patterns

Despite the lack of an overall arousal effect, the distinct kinematic signatures for each object (as shown in our test of Hypothesis 1) reveal how emotional content shapes motor behavior [6]. Fear-inducing stimuli (spider) elicited rapid, frequent grasping movements, potentially reflecting defensive or exploratory responses to threat. Conversely, disgust-evoking objects (donut) produced minimal contact, consistent with avoidance behaviors. Neutral objects (box, toy) showed intermediate patterns, while the comfort object (pig) generated moderate but sustained interaction. These findings extend beyond simple arousal effects, suggesting that specific emotions activate distinct motor programs [8]. The spider's high activity may reflect evolutionary preparedness for threat detection, while disgust-related avoidance serves protective functions against contamination.

C. Visual vs. Non-Visual Processing

Contrary to expectations, visual preview did not significantly affect overall grasping behavior. The non-significant group difference ($p = 0.791$) suggests that tactile-emotional responses may be as robust as visual-emotional responses in driving motor behavior. The finding has important implications for understanding multisensory emotion processing and supports the role of haptic perception in emotional evaluation.

The greater variability in the NON-VISUAL condition may reflect individual differences in tactile sensitivity or emotional processing when visual cues are absent. This variability could be leveraged in future studies to examine individual differences in emotion-motor coupling.

D. Methodological Insights

Our smartphone-based motion tracking approach successfully captured emotionally relevant motor variations, demonstrating the viability of accessible technology for behavioral research. The three-category movement classification (grasping, holding, other) effectively differentiated object-specific interaction patterns. The alignment between the intended emotional categories and participant responses validates our object selection strategy. However, the predominance of neutral responses (47% of reports) suggests that naturalistic settings may attenuate emotional responses compared to laboratory paradigms.

E. Applications and Implications

Human-Computer Interaction: Real-time analysis of hand kinematics could enable emotion-aware interfaces that adapt to user affective states during object manipulation tasks.

Clinical Applications: Non-invasive kinematic assessment may complement traditional emotional evaluation methods, particularly for populations with communication difficulties.

Affective Computing: The emotion-specific motor signatures identified here could inform machine learning models for automatic emotion recognition in human-robot interaction scenarios.

F. Limitations and Future Directions

Several limitations constrain interpretation. The sample size (n=20) limits statistical power for detecting subtle effects. The naturalistic setting, while ecologically valid, reduced experimental control over confounding variables. Future studies should incorporate physiological measures (heart rate, skin conductance) to validate emotional arousal independent of self-report.

The video analysis methodology, while accessible, lacks the precision of specialized motion capture systems. Direct force measurement would provide additional insights into grip strength variations. Longitudinal designs could examine whether emotion-motor coupling patterns remain stable across sessions or show habituation effects. Future work should explore individual differences in emotion-motor coupling, investigate developmental aspects of this relationship, and examine how cultural background influences emotional responses to objects.

VI. CONCLUSION

This study demonstrates that emotional responses to objects systematically influence hand movement patterns during grasping tasks. Using accessible smartphone-based motion tracking, we identified distinct kinematic signatures for objects evoking different emotions, with fear-inducing stimuli generating the highest motor activity and disgust-evoking objects producing avoidance behaviors.

Our findings contribute to understanding emotion-motor coupling in several directions. First, we provide evidence that object-specific emotional responses translate into measurable kinematic differences, supporting theories of embodied emotion. Second, we show that emotional valence and approach-avoidance tendencies may be more predictive of motor behavior than arousal level alone. Third, we demonstrate that tactile-emotional processing can drive motor responses as effectively as visual-emotional processing.

The practical implications extend to human-computer interaction, clinical assessment, and affective computing applications. Real-time kinematic analysis could enable emotion-aware technologies that respond to users' affective states through their natural hand movements. For clinical populations with limited verbal communication, kinematic assessment offers a non-invasive window into emotional processing.

Future research should address the limitations identified here through larger samples, physiological validation, and examination of individual differences. The integration of emotion and motor control revealed in this work opens new avenues for understanding how feelings shape actions in human behavior.

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