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Identifying Container Contents by Touch: Extending Container Haptics to Qualitative Judgments

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***Abstract*— Can people identify the contents of sealed containers through touch alone? While prior work in container haptics has focused on quantitative assessments (e.g., number or amount), we explore the extent to which humans can make qualitative judgments about a container's content. Participants were given a single haptic exploration per container and asked to identify what dry food item was inside. Results show that even without visual or auditory cues, people could infer container content with surprising accuracy, especially for coarse or irregular textures. These findings broaden the scope of container haptics beyond enumeration and estimation.**

I. Introduction

Touch is a powerful sensory modality for perceiving object properties like shape, size, and texture. However, while most haptic research assumes direct contact with the object of interest [1], everyday tasks—like shaking a box or squeezing a pouch—often involve perceiving content that cannot be contacted directly. This phenomenon, termed *container haptics* [5], refers to the ability to extract meaningful information about contents via a container interface. While past studies have examined quantities such as liquid levels [2], object motion [4], and numerosity [5], [7], content identification has not been formally tested.

II. Method

A. Participants

Three studies were conducted with a total of 70 participants. All participants were right-handed, reported normal tactile acuity, and provided informed consent in accordance with Bentley University's IRB guidelines.

B. Materials

Each study used a set of identical opaque lidded cylindrical plastic containers (diameter 7 cm, height 5 cm) filled with dry food items varying in texture, weight, and sound properties as shown in Fig. 1: cloves, flour, granola, lentils, couscous, vermicelli, rice, bulgur, and nigel. Participants were blindfolded and, in addition, wore noise-canceling headphones in Studies 1 and 3.

C. Design and Procedure

In all studies participants explored eight containers one at a time by shaking it for a few seconds using one or both hands. The response format and available sensory cues varied across study. **Study 1: Forced Choice: Touch and Sound.** Participants ($n = 30$) chose their response from a fixed list of eight candidate items. They had access to both tactile and auditory cues. **Study 2: Forced Choice: Touch Only.** Participants ($n = 7$) completed the same task as Study 1 but without auditory cues. **Study 3: Free Naming: Touch and Sound.** Participants ($n = 33$) named what they thought the content was without a list; they were only told that the content were dry food stuffs. Participants had access to both tactile and auditory cues.

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Fig. 1. Containers used in the experiment, filled with different dry food items: Left to right) top: cloves, flour, granola, lentils, bottom: couscous, vermicelli, rice, bulgur, and nigel.

III. Results

A. Studies 1 and 2: Proportion Correct

As shown in Fig. 2, having access to tactile and auditory cues (Study 1) yielded above chance performance (dotted line). With tactile cues only (Study 2), performance was significantly less accurate and at around chance level.

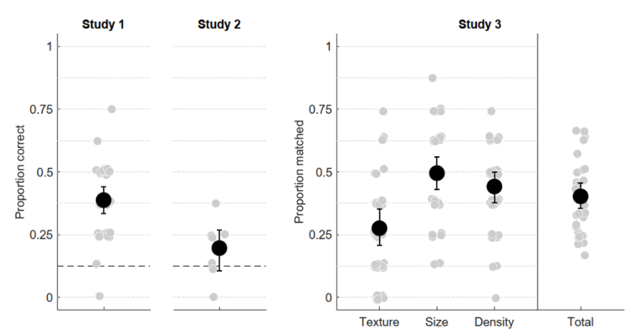

Fig. 2. Performance across the three studies. Left: proportion correct in Study 1 (touch and sound) and Study 2 (touch only). Right: proportion of feature matches in Study 3 by dimension and overall. Black dots = means; gray dots = individual scores; error bars = 95% CI based on empirical bootstrap (n = 10,000).

B. Study 3: Feature Matching

Responses were analyzed with feature-matching; categorizing them along three dimensions—*texture*, *size*, and *density*. Each dimension was then scored as matching (0 = no, 1 = yes) with those of the actual food items—as shown in Table I. A total match score was calculated by summing across the three dimensions (range: 0–3). While exact matches were rare, participants reliably matched over 40% of content features on average, indicating that meaningful perceptual information was still accessible through haptic and auditory cues. Fig. 2 shows that *size* and *density* showed the strongest and similar agreement, while *texture* showed the weakest agreement.

TABLE I
STIMULI CLASSIFICATION USED FOR FEATURE MATCHING

Food Item	Texture	Size	Density
Nigella	Hard/Coarse	Small	High
Cloves	Hard/Coarse	Large Pieces	Low
Couscous	Granular	Small	High
Flour	Fine	Very Fine	High
Vermicelli	Chunky	Small	Medium
Granola	Chunky	Large Pieces	Low
Bulgur	Granular	Small	High
Lentils	Hard/Coarse	Small	Medium

IV. DISCUSSION

This work set out to investigate whether people can identify the contents of a sealed container by touch alone. The three studies reported here explored this question under varying sensory conditions, revealing important insights into the role of haptic and auditory cues in content identification, and extending the scope of prior container haptics research [5], [7].

Study 1 aligns with earlier findings that emphasize the diagnostic role of auditory cues in perceiving the amount or nature of container contents [2], [3]. Auditory signals in our study likely enhanced the salience of internal object motion, facilitating more confident identification. In contrast, Study 2 removed auditory cues and relied solely on haptic exploration. Participants in this condition performed much less accurately. Although the sample size was small, the results raise the possibility that haptic information alone may be insufficient to support reliable content identification—at least for certain materials or under brief exposure. These observations resonate with findings by Overvliet et al. [8], who found that auditory cues consistently outperformed haptic cues when the two were compared directly.

Study 3 explored content identification in a more ecologically valid manner by allowing participants to freely name the content of containers based on tactile cues only. Although participants rarely provided the exact item name, they were able to match perceptual features such as texture, size, and density. These findings build on prior work suggesting that touch can be used to extract structural or material features of concealed objects [5]–[7]. In this case, participants may have formed partial inferences rather than engaging in category-level recognition. That is, they could detect properties like granularity or compressibility, but lacked enough information for full semantic labeling.

V. CONCLUSION AND FUTURE WORK

Our findings suggest that container content identification is a process grounded in the perception of diagnostic physical features. Moreover, this process appears to be part of a broader multisensory mechanism. While tactile cues alone *can* support meaningful perceptual judgments when those features are distinct enough, adding auditory cues significantly enhances identification accuracy.

A key goal for future work will be to understand how haptic and auditory modalities interact in naturalistic settings. Thus, we aim to examine the perceptual weights of auditory and haptic cues by systematically manipulating their reliability but also highlight the need to understand how perceptual systems weigh available cues depending on context, content type, and exploratory strategies. Future work will also aim to replicate and generalize the current findings by introducing a broader range of container contents, such as liquids or heterogeneous materials that differ in fluidity, compressibility, or internal motion. Finally, we are interested in exploring the potential for crossmodal illusions in virtual environments. Future studies will examine what happens when incongruent auditory and haptic cues are combined, and whether similar effects emerge when haptic cues are paired with conflicting visual information. Such investigations could offer deeper insight into how container content is inferred in both real-world and mediated sensory contexts.

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